

EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

VOL. 62, NO. 20, PAGES 497-504

MAY 19, 1961

Particles and Fleids-Interplanetary Space

5310 Cosmic Rays
AS ACALYTIC EXPRESSION FOR THE RADIAL DEFENDENCE
OF THE DIFF'SION COEFFICIENT FOR QUIET TIME
ENDING RALICA AND ONNOWN IN THE MELIOSPERE
S.C. Haish and A.K. Fichter (Max-PlanckInseltut für Astonomie, Katlenburg-Linden),
West Cortanny)

West Corrany)
Taking recent observations of the differential isdial gradients and energy spectra of quiet time competit particles and different energies and many a large believement or radial distance from D.) to 18 AU into account, we about that the transport equation for these verticles (Fobser-Planck equation) for the radial distance are differential equation for the radial distance or differential equation for the radial distance or efficient, which then can be releved analysiscally. For corrected we then discuss the radial dependence of their diffusion of ficient. J. Ceaphys. Res., Blue, Paper 140619

5310 Cosmic Rays
FILATIVISTIC COSMIC RAYS AND CO-ROTATING INTERACTION PACHONS
5. F. Duggal (Bartol Research Foundation of The
Franklin Institute, University of Delmare,
Remark, Celmare 19711) B. T. Isurutani, M. A.
Formantz, C. H. 7843, and E. J. Smith
Analyses of relativistic galactic cosmic ray
intersity variations have been conducted to determine the nature of the modulations that are
related to the presence of co-rotating interaction regions (CER) in interplanetary space,
The co-rotating interaction regions have been
identified from the plasma and fold one The co-rotating interaction regions have been identified from the plasma and field observations recorded by Floreer IO and II spacecrafts
during the portod 1972-1974. Into investigation
has established that the mateomic intensity recorded at the polar stations Thube and McMardo
vertake the estream associated with the CIR
vertake the polar stations Thube and McMardo
vertake the polar stations Thube and McMardo
vertake the polar stations Intensity recovers any for those CIR associated stream in
which a neutral baset is faceded. In contrast,
getaignetic storms are related to CIR-stream;
with or without neutral sheets. Taken together,
their maurits suggest that the ostensible effect
cles is privarily a consequence of drifts relatdd tir reutral sheets.

1. Seaflys. New. Blue, Pages Janaa. to seutral sheets. Southym. Rom., Bluc, Paper 140646

SOLD COUNTY PARTY OF THE SECTION OF AND

PARTICLE ART CFACITIES IN THE MILLIONNIER AND PARTICLE PRIVATE CONTACT REVENUE, Jr. 1Physics Department, University of Rev Rampshire, Derham, Mr Oldza) and John A. Lo, be, ed

E - coronameter, solar wind, and neutron beniter data aga and de estimate the letitedinal gradient of 1950 yearton in the relicipator at 1 AD during 1955 and 1975, the reversal of sign of the gradient art hetween 1963 and 1975 and the strong positive in this data gradient in 1975 predicted by models in which drifts are deminant are bent observed. Geograps, Res., Rest., Paper 160005

5)10 Solar wind angustic fields successful and an imperfuserant succession and in-a confusations. Salide and in-a confusations L. Surings (MARNGOSSANE Speed 2)12th Conterputations for Extensor results Physics (Franchele, 10 2077) S. Sittler, F. Mariani and B. Schwenk.

and I. Salveton Sugartite field and plasma data from 5 space-

craft (Voyager 1 and 2, Helios 1 and 2, and 1MP-8) ware used to analyze the flow behind an interplanetary shock. The shock was followed by a turbulent shearh in which there were large fluctuations is both the strength and direction of the magnetic field. This in turn was followed by a region (angustic cloud) in which the magnetic field weters were observed to change by rotating nearly parallel to a plane, consistent with the passage of a magnetic loop. This loop extended at least 100 in longitude between 1-2 AD, and its radial dimension was approximately 0.5 AU. In the cloud the field strength was high and the density and temperature were relatively low. Thus the dominant pressure in the cloud was that of the magnetic field. The total pressure inside the aloud was higher than outside, implying that the cloud was expanding as it moved outward, even at the cloud at 2 AU. The sometim flux of the cloud at 2 AU was not higher than there of the passbock pleasa, indicating that the cloud was not driving the shock at this distance. It is possible, however, that the shock was driven by the cloud closer to the sun where the cloud may have noved faster. An extraordinary filmant was observed at the rear of the cloud. It was bounded by current eheat whome orientations were preserved over at lease 0.12 AU and which was related to the plane of maximum veriance of the magnetic fields, solar wind plasmae, anguetic loop].

J. Gaophys. Rea., Blue, Paper 1A0759

nagnetic lopp). J. Geophys. Rea., Blue, Paper 1A0759 5390 Solar wind plasma
INVERSE MAPPINS OF SOLAR WIND FLOWS
V. Pizzo (High Allitude Observatory, NCAR, P.O.
Box 3000, Boulder, CO 80303)
Box 3000, Source of Source Valocity Lechnique is Sox 1000, Boulder, CO 8030/)
The widely-used constant velocity technique is capable of mapping solar wind structures seen near 1 AU back to the vicinity of the sum with only limited accuracy. This report points out that relatively sophisticated MHD numerical models can be applied to this 'inverse' mapping problem, promising hetter accuracy, especially in the region of the stream front.

J. Maophyn. Res., Blue, Faper 140642

Particles and Fields ionosphere

Sign Airglow
OPTICAL OBSERVATIONS OF THEMOSPHERIC DINARICS
AT ARREINO
R. G. Burnside (Space Physics Remorch Imberatory, University of Michigan, Ann Arbor, MI
(Abi03) F. A. Berryo, J. W. Merivether, Jr. and
J. C. G. University of Michigan, Ann Arbor, MI
(Abi03) F. A. Berryo, J. W. Merivether, Jr. and
J. C. G. University of Michigan Charles, Jr. and
J. C. G. White Michigan of Michigan Charles, My
using a Paby-Front Interferenter to measure
the Doppler infit of the mighties O(10) 650 an
edivation. In general, the highest equiphorused
wind velocity is pheaved at about 2100 L87.
Midnight approaches and sometimes, but by no
magnitude of the squaences after admirght. The
sagnitude of the squaences of the admirght in practice
tand Spring wonths, the sound wind blows date;
very theorem of the state of the velocity
tending to decrease to a fairly require lashion
from about 115 a see, 1 st 2100 L87 towards
apply 0400 L87. In Separa the phittern in
agrifue, and a wanter of young the pattern in
agrifue, and a wanter of young the
age; the squaence of the search of the phittern in
agrifue, and a wantered velocity of some 50 p.

Rec. to any be at 4 santered by 0400 L87.

Significant horisontal wind gradients are often observed in the moridional direction, but not in the zonel direction. Near midnight especially, during both the equinox and scamer months, the equatorward wind is often greater to the north of Aracibe that to the south. We interprate this as heing an effect of the pearshe of the midnight equatorial pressure maximum to the south of the shift of the shift of the state of several tempurature with the interference of several tempurature with the interference of and deed show that, between 0100-0200 LST, the neutral temporature to the south of Aracibe is enhanced by some 40°F over that to the north J. Geophys. Res., Blue, Paper 140610

THE AUBORAL 2145% FRATURE

A. Dalgarno (Harvard-Smithmonian Canter for Astrophysics, Cambridge, MA 02138 USA) C.A. Victor and T.W. Harvards:
Laboratory data are used to argue that the excitation of the Nil doublet near 2145 % by electron impact on Ny occurs through the sjaction of an electron from the long mobital. The trons accition probably accessed 10-16 cm², as is required if electron impact excitation of Ny is the source of the autoral feature. By extrapolation along the importance acquence, we estimate a lifetime of 5.8 ms, in harmony with recent ab initio calculations. The auroral observations then imply a rate coefficient for quenching of N*10591 tons in the atmosphere of lone than 10-10 cm³ cm²—1. (Atmit n.troqon).

3320 Electric (leids
FIELD LINE EQUIPOTENTIALITY AND ION-NEUTRAL
COLLISION FREQUENCIES IN THE DYNAMO RESION
DEDUCED FROM SAINT-SANTIN ION DRIFT MEASUREMENTS
C. Taleb (CNET/Centre de Recherches en Physique de
Provironnement Terrastre et Planétaire, 38-30 rue de
Général Lecterc, 92131 Issy-les-Moulineaux, Prancel
M. Blanc

We analyse three-dimensional ton drift data from the Saint-Santin incoherent scatter facility to test experimentally the theoretical description of ion transport the ionospheric dynamo layer, and to deduce electric the ionospheric dynamo layer, and to deduce electric fields and ion-neutral collision frequencies from the observed drifts.

Using a geometrical representation of the isa momentum equation, we show that at middle initialist, because horizontal neutral wind influences ion medical because horizontal neutral wind influences ion medical both purallel and orthogonal to the floid lines in the both purallel and orthogonal to the floid lines in the both purallel and orthogonal to the information contained in the consideration of the properties of the standard theoretical through the profile one can deduce the north-south perpendicular profile; one can deduce the north-south perpendicular profile; one can deduce the north-south perpendicular component of the electric fleid function of height is the E-region from Saint-Santin drift data. We find that its altitude variations remain within the experimental altitude variations remain within the experimental interestical assumption of equipotential field these.

mecretical assumption of equipotential field incommits.

Second, assuming that the electric field is constant in allitude, one can determine the lon collision fathers are of the lon collision frequency to the lon give ratio of the lon collision frequency to the lon give ratio of the lon collision frequency to the lon their frequencies, thus obtained for each of the other frequencies, thus obtained for each of the other seasons, are found to gompare reasonably well with the seasons, are found to gompare reasonably well with the seasons, are found to gompare reasonably well with the seasons of the sea

Farthquake Seismograph Development: A Modern History—Part 1

Ben S. Melton

The years from 1948 through 1976 saw numerous changes in electrodynamic-type earthquake seismographs. During this period, these seismographs and their associated amplifiers, recorders, timing systems, and power supplies were adapted for worldwide service under many operating conditions. These developments required and led to a better understanding of the fundamental limitations on design, ultimately allowing small but adequately sensitive instruments to be built for installation in cased holes, thereby avoiding undesired local surface disturbances. The recording system developed within this period permits ready review and compact storage of seismological data.

Introduction

This history of development of modern earthquake seismographs covers the period from 1948 through 1976. This auhor's involvement with many decisions and occasional contributions is documented by personal records and some pubished reports. Some personal recollections of several individuals who were involved over the same period of years are included. All of the well-known American seismologists who were active during that period influenced and supported the developments by their advice, so the engineering advances described here were of a nature to forward the seismological art in a practical manner.

in writing such a history, one needs to compose a presentation easily followed by the reader rather than to follow a strict outline of dates. My choice is to present first the sequential history of selsmometers, followed by that of amplifiers, then recorders, and finally, timing systems. This inwives a slight repetition of material for the case in which a modulator has become a part of the seismometer, but in genwal the sequence of developments was independent for saismometers, amplifiers, recorders, and timing systems. However, because of the length of this chronicle it has been separated into two parts. The first part will cover seismomelers, the second, the remaining components. For the reader's convenience, the figure numbers will continue through the second part, which will be published in a forthcoming issue.

Prior to 1948, earthquake selsmology in this country had an academic background. As a rule, a seismologist would purchase or have built a seismograph Instrument or instruments suited to his interest in particular seismic phenomena. The different apparent surface speeds of seismic phases composed of compressive and shear waves enabled him to Infer the distance of a given earthquake. Characteristically, one instrument or selsmometer might have a springsupported mass constrained to move vertically and with a

TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

Send double-spaced manuscripts (four copies) to Eos. AGU,

Allor: A.F. Spilhaus, Jr.: Associate Editors: Claude J

Allegre, Peter M. Bell, Kevin C. Burke, Arnold L. Gordon, Kristina

Kalsaros, Gerard Lachapelle, Christopher T. Russell, Richard A. Snith, Sean C. Solomon, Carl Kiselinger; News Writer: Barbara I. Richman; Editor's Assistant: Sandra R. Mark; Eos Pro-

duction Staff: Patricia Bangert, Margaret W. Conelley, Eric Gar-ison, James Hebbiethwaite, Dae Sung Kim, Michael Schwartz.

J. Tuzo Wilson, President; James A. Van Allen, President-Elect;

retary, A. F. Spilhaus, Jr., Executive Director; Waldo E. Smith, Executive Director; Waldo E. Smith, Executive Director;

dverising that meets AGU standards is accepted. Contact Elleen

Eos, Transactions, American Geophysical Union (ISSN 0096-3941)

Is published weekly by the American Geophysical Union from 2000

Forida Avenue, N.W., Washington, D. C. 20009. Subscription available on request. This issue \$5.00. Second-class postage paid at Washington.

Copyright 1981 by the American Geophysical Union. Material published in the issue may be photocopied by individual scientists for research or described to the Population in electronical to use short

research or classroom use. Permission is also granted to use short

quotes and figures and tables for publication in scientific books and founds.

Cever. Scanning electron photomicrograph of an experimentally produced fracture surface in an Arkansas River sand grain. Composition is quartz, except feldepar in upper left. Scala: photo width hackles (upper left) and Wallner lines (center). (Photo courtesy Liss, Okla.)

ournals, For permission for any other uses, contact AGU Publication of permission for any other uses, contact AGU Publication of permission for any other uses.

Icalions Office, 2000 Florida Avenue, N.W., Washington, D. C.

O. Simms, advertising coordinator, 202-462-6903.

Washington, D. C., and at additional mailing offices.

edith, General Secretary; Carl Kisslinger, Foreig

Officers of the Union

2000 Florida Avenue, N.W., Washington, D.C. 20009, or send them directly to one of the associate editors with a copy to the

The Weekly Newspaper of Geophysics

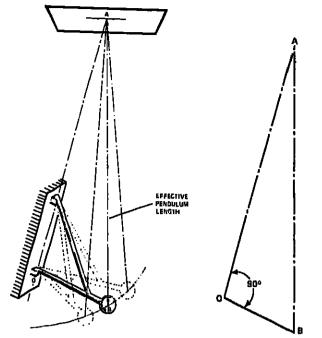


Fig. 1. Geometry of a horizontal-component seismometer, showing the relation of its hinge axis to the vertical.

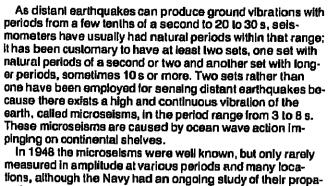
natural period of about 1 s. A different instrument, or rather two more instruments, would have masses hinged on a vertical mast and constrained to move horizontally. These seismometers would be oriented so that one could respond to north-south motion, the other to east-west motion. Their periods would be on the order of 2 or 3, sometimes as much as 20 s. The short-period vertically responding instruments would best respond to the refracted compressive waves that travel through the earth's interior, white the horizontal mode instruments would respond to horizontal components of the longer-period shear waves.

To record distant earthquakes, the motion of each seismometer had first to be magnified by mechanical, optical, or electrical means. The early mechanical systems were easily analyzed in terms of response to earth movement, and these instruments were well covered by Dewey and Byerly [1969]. Their history of these instruments ended with the beginning of the 20th century. They mentioned the electrodynamic seismograph with galvanometer, which was introduced by Galitzin [1903], but did not discuss it.

When Prince Boris Borisovich Golilsyn (Galitzin) coupled the already well-known galvanometer to a seismometer pendulum through an electrical coil moving in a magnetic field, he laid the foundation for engineering development of the modern electrodynamic seismograph. Galltzin's galvanometer mirror deflected a light beam which was focused on sensitized paper that was carried on a rotating drum, thereby tracing a waveform that was related to the earth's vibration. Seismologists followed this earliest documented work by devising various models for different purposes. Among better known names within this country are those of Wenner [1929], Benioff [1932], and the W. F. Sprengnether instrument Company, Inc., of St. Louis, Missouri, which built seismometers for various seismologists. In general, the electromagnetic seismograph in use until 1950 employed this photographic registration on film or paper wound around a slowly rotating drum. The drum was translated along its axis to allow several hours of recording on the same strip or sheet. This system, the electromagnetic or electrodynamic seismometer with its associated galvanometer and photographic recorder, provided high and controllable magnification at periods of interest. The seismometer could now be installed in a location less subject to nearby disturbances, and the recorder could be located more accessibly. Such was the status of most instruments in observatories before about 1950. Many obser-

vatories still use this arrangement. However, the development of nuclear weapons after 1945. and national concerns about the possibility of clandestine tests of such weapons, led to demands for some means of detecting such tests, seismographic monitoring being one obvious choice. In 1947, Chief of Staff General Elsenhower assigned this task to the Signal Corps. With the reorganization that resulted from the emergence of the U.S. Air Force as a separate branch of the armed services later that year, the first secretary of defense, James Forrestal, reconfirmed the assignment to the Air Force Office of Atomic Energy, Funds became available to this office in 1948, and a staff of civilian scientists was assembled under a military structure. J Allen Crocker of that staff hired this author as a geophysicist in late

Review of available information on seismographic instruments in 1948 and 1949 showed that none was adapted for rapid manufacture and standardization, which would facilitate use by anyone other than an experienced seismologiet. However, basic knowledge of mechanical and electrical design was available in some government laboratories. The David Taylor Model Basin in Carderock, Maryland, a Navy facility, had already designed some long-period horizontal component seismometers for use in tracking storm microselsms. These were built by Reed Research Inc. of Washington, D.C. The Stanley Aviation Corporation of Denver, Colorado, was low bidder on a contract to develop 'short-period' three-contponent selamometers with associated amplitiers, etc., for the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. Both of these systems drove Brush Development Company's multipen recorders through vacuum tube amplifiers



Basic Mechanical and Seismological Problems

In 1948 the microselsms were well known, but only rarely measured in amplitude at various periods and many locations, although the Navy had an ongoing study of their propagallon speeds and directions relative to ocean storms. On the other hand, the natural period of the Navy seismometers was a handicap to the study of weak short- and long-period earthquake waves from great distances. Thus the scientific staff under Air Force auspices directed attention to separate seismometers for short and long periods.

Ultimately, the natural period designed into any earthquake seismometer depends upon the earth's gravity. Horizontal component instruments are designed like a 'garden gate," that tends to swing shut because its hinge axis is aligned to intersect the vertical above the mass of the gate itself. Vertical component instruments must have a spring force that will neutralize the earth's gravity and allow the mass to have a rest position within a limited travel amplitude while sensing earth vibrations. Figure 1 shows the principle of the 'garden gate,' in which the force of the earth's field along AB is reduced by the cosine of the angle OAB. The spring force that supports the mass of a vertical component Instrument should be linear with respect to soring extension. and for a simple coiled spring this becomes a large physical dimension for periods greater than a few tenths of a second. The length of a simple vertical coiled spring that supports a mass must be such that its extension E is given by the for-

$E = gT^2/4\pi^2$

where g is the acceleration of gravity, T is the period in seconds. Thus for a 10-s period the spring stretch E would be about 25 m. Although LaCoste had devised his long-period suspension by 1934, and LaCosto and Romberg analyzed it in their 1942 patent of a 'force measuring device,' it was not well understood by seismologists in 1948 or even much later. when LaCoste was building and selling practical gravity me-

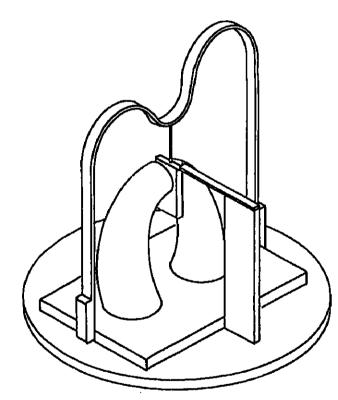


Fig. 2. Sketch of the spring suspension of the output coil of the Stanley short-period vertical-component seismometer.

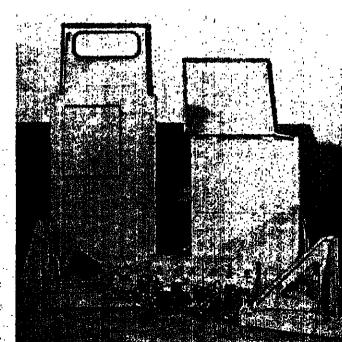


Fig. 3. OTMB horizontal-component selamograph system,

GRAVITY

VERTICAL

TRIFLEXURE

HINGE

Electrodynamic Seismometer

handling and shipping.

Fig. 15. LaCoste suspension as employed in the symmetrical tri-

Justification of the Mass Requirement for the

axial selsmometer; & represents the angle of tilt.

Throughout the period covered by this history, justification

of the magnitude of the seismometer's inertial mass was a

major concern. The mass had to be sufficient to deliver ade-

quate energy for recording minimal earth vibrations. On the

other hand, an oversize mass would increase problems of

seismometer designed to detect weak long-period earth-

quake waves. The practical example taken was a 10-kg

In 1963, using NBS Report 7454 as the reference, I made

calculations to determine the minimum acceptable mass for a

mass seismometer, which had a natural period of 15 s, close-

and it was to be used in a phototube amplifier, a device which

In NBS 7454, ω_o , ω_o , and ω_m refer to the natural angular frequencies (radians per second) of the seismometer, galva-

respectively; $\tilde{\psi}$ is the ratio ω/ω_{m} , where ω is the variable; λ_{ω}^{*} .

 λ_{cl} and λ_{m} refer to fractions of critical damping for the seis-

mometer, galvanometer and geometric mean $(\lambda, \lambda_s)^{1/2}$, respectively; y is taken as earth displacement, and θ refers to

the angular deflection of the galvanometer coil, so the frac-

an of coil deflection. Similarly, a fraction MIK is the ratio of

 $4\lambda m^2 M/K (y/\theta)^2 = \phi^{-6} + \phi^2 + B^2 - A^2$

 $A^2 = 2(\omega_0^2 + \omega_0^2)/\omega_m^2$

seismometer mass to galvanometer moment of inertia.

Equation (6.3.22) in NBS 7454/NBSIR 76-1089 is

tion y/e represents the earth displacement in meters per radi-

nometer, and geometric mean of these frequencies $(\omega_0 | \omega_q)^{1/2}$.

ly coupled to a galvanometer that was recently designed by

Forest K. Harris of NBS. That galvanometer had a natural

period of 100 s and a moment of inertia of 4 × 10⁻⁶ kg m².

will be described in part 2 of this history.

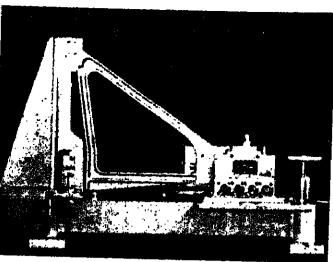


Fig. 4. DTMB horizontal-component seismometer.

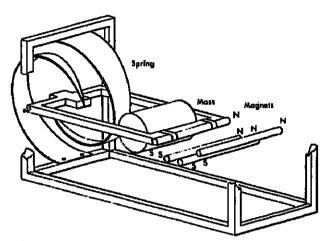


Fig. 5. Sketch showing principal construction features of the DTMB vertical-component selsmome

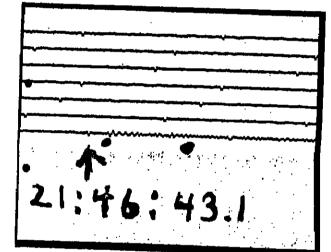


Fig. 6. Seismic record trace of the Enlwetok nuclear explosion of July 24, 1946, at 21 h 34 min 59.7 s GMT.

Early Designs of Sensitive Seismographs

The Stanley short-period seismographs and the David Taylor Model Basin (DTMB) long-period seismographs were available in 1948. The Stanley instruments provided vacuum tube amplification of the voltage generated by a coil moving in the flux field of a permanent magnet. The magnets used were surplus magnetron magnets. Use of these was a factor in allowing Stanley to submit the lowest bid to the Department of Terrestrial Magnetism (DTM). The vertical (component) Stanley seismometer used the coll as its mass. The impregnated coil was supported from a strip of spring phosphor bronze (later replaced by 'iconel') that was fastened rigidly at its ends but bent into a shape resembling a 'bishop's hat, a name which stuck to it at the time. Figure 2 is sketched to show the essential parts of this device, which, by its nonlinear force, tended to keep its vertical dimensions within reasonable bounds while supporting the mass-coll. This arrangement was never successfully stabilized, however. The horizontal component Stanley seismome garden gate principle. Figure 3 shows the DTMB assembled system. The DTMB seismometers did not generale a salamic signal from a coil moving in a magnetic field. Instead, they used a capacitance bridge, one arm of which was the capacilance between a 'condensor button' and part of the pendulum. Some mechanical damping was provided by a dashpot that contained damping fluid.

The capacitance bridge network was fed by 100 kHz from a crystal controlled oscillator and buffer amplifier. When the bridge was balanced—the pendulum presumably centered in its Iravel—there was no signal output to an amplifier-demodulator combination. Any displacement of the pendulum unbalanced the bridge, supplying a 100-kHz signal with magnitude prosumably proportional to displacement and phase depending upon direction of displacement from the balance point. A phase-sensitive detector, or demodulator, provided a signal at seismic fraquency. This seismic signal followed two paths. One was through amplitters to the Brush recorder, The other path was through yet another amplifier to a positioning electromagnet whose field was arranged to oppose the field of a permanent magnet mounted on the pendulum. Such a negative feedback reduced the natural period of the pendulum, thereby reducing sensitivity at the longer periods by effectively increasing the passband for seismic signals. Figure 4 shows the DTMB horizontal component seismometer. The

electromagnet feedback case is back of the pendulum in this photograph.

By mid-1949 the DTMB group, under George Cook, had bullt an experimental long-period vertical component seismometer whose principles are illustrated in Figure 5. The spring force here was applied as a torque at the hinge end of a long arm that supported the mass, and several fixed permanent magnets offered a measure of control and stabilization by opposing the field of a magnet mounted on the selsmometer arm. The centering of the mass was alded by proper positioning of magnets below the arm, and the period was affected by the magnet horizontally opposite the arm, producing periods as long as 30 s or more. The torque assembly was comprised of strips of spring metal which had low-temperature coefficients of expansion and rigidity, but the system could not be stabilized for actual service and was never de-

One set of the DTMB horizontal component selemographs was put into experimental field service by Beers and Heroy, a partnership between Roland F. Beers and William B. Heroy, Sr., In Troy, New York. Of that organization, staff members active today include Jack H. Hamilton, Braden B. Leichliter, and Martin Gudzin, all currently associated either with Teledyne or Teledyne Geotech in Garland, Texas, hereafter referred to simply as 'Geotech.' Seismologist Carl Romney, a graduate student recommended by Perry Byerly, was with the Troy organization originally.

The DTMB seismographs were in the field near Troy, New York, and operating at the time of the magnitude 8.7 earthquake of August 15, 1950, which was located 28.5°N, 96.5°S (eastern end of the Himalayan range). But when word of the quake was received through Carl Romney, 'Brad' Leichliter visited the observatory and found the operator asleep. The excuse: 'When the pens went wild, I decided it was (instrument) noise and shut it down.' However, consideration of the logistics problems involved in supplying storage batteries for vacuum tube filaments plus large quantities of dry batteries for plate current resulted in discontinuance of the manufacture and development of both Stanley and DTMB instruments. This would have happened even had it been possible to improve them. Power supplies with long-term stability and which were led from the ac power line were not available in 1948 and the early 1950's.

Reconsiderations of Practical Seismographs and Combinations

The disappointing experience with these efforts to create sophisticated seismograph systems led to reconsideration of commercially manufactured instruments. Investigation showed that a Benioff short-period seismometer, with galvanometric registration on film, located in California, had clearly recorded the Eniwetok nuclear explosion of July 24, 1946, that was known as 'Bikini-Baker.' The print of Figure 6 shows this record section on the lowest trace. The square pulses on all traces are 1 min time marks. This record was in no sense surprising, but its existence, and political expediency, suggested that the best course was to procure and instali Benioff Instruments as quickly as possible. Hugo Benioff and Francis Lehner of Lehner & Griffith allowed Geotech to update manufacturing drawings, and Geotech put both verti-

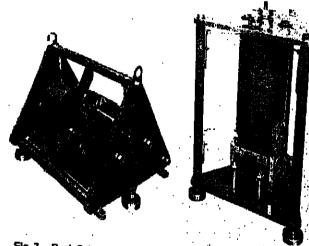


Fig. 7. Benioff short-period selsmometers: (a) vertical component, (b) horizoniai componeni



Fig. 8: Johnson-Matheson selemometer and case.

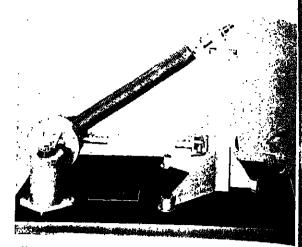


Fig. 9. Press-Ewing long-period vertical-component seismon with LaCoste suspension

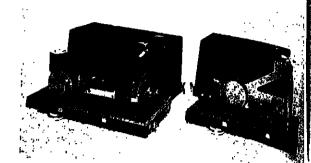


Fig. 10. Geotech long-period vertical- and horizonial-component selamometers.

cal and horizontal seismometers into production. Thesever sions are shown in Figure 7.

Benloff's original paper, published in 1932, pointed out that the instrument's magnetic structure (technically, a variable rejuctance' structure) had the effect of reducing spring stiffness, thereby shifting the natural period slightly above ahal second. Also, that paper discussed the advantages of using a long-period (i.e., 14-s) galvanometer with his short-period seismometer. By 1957, Benioff had put in service a seismo graph designed to respond to the normal dilatational modes of the earth's vibration. He housed one of his variable reluc tance seismometers in a stiff cylindrical steel chambertor duce its response to barometric pressure variations. Tothis selsmometer he connected a galvanometer that had a nate ral period of approximately 10 min. The seismometer paid was adjusted to about 2 s. The external critical damping 14 sistance of the galvanometer was 135,000 ohms, and the transducer winding had a resistance of 135,000 ohms. To reduce the response to short-period waves, a capacitor 200 μ F was shunted across the transducer, followed by 135,000-ohm resistor in series with the galvanometer. This arrangement makes the response constant to ground displacement within ±3 dB from 2 to 6000 s. When capacitor and resistor are removed, response to velocity is constant over the same range. However, today's negative attitudes about galvanometers have tended to close this avenue, even though it was investigated by Wenner [1929] and reinvestgated by the National Bureau of Standards (NBS) about 1960, in a study by D. P. Johnson and H. Matheson of the

In addition to their theoretical studies, Johnson and Main oson, with the aid of master machinist Henry A. Schmidt, also of NBS, designed a short-period vertical componentsels. mometer in which the permanent magnet was used for the mass, while the electrical coll was mounted in the frame. Fig. ure 8 shows this instrument. A period of 0.8 s was achieved by supporting the magnet mass from three levers, which reduced the force of very stiff springs. The springs were made very compact and could be given a prestretch in their normal position. The effect of spring stiffness was reduced by a factor of 10 in this manner; this was equivalent to making the springs 10 times as long. These instruments were quite rufged, and some of them eventually replaced the vertical conponent Benioff selsmometers. Some details of this instrument were shown and discussed by Melton and Johnson

'NBS Report 7454 was first issued in 1962. The final docu NBSIR 76-1089, was issued in 1976; but this report riever enters the public literature because its authors declined to discuss early papers covering the same material. In lieu of such discus defined all of their variables and included those of the earlier lief ture, where appropriate, for the reader's reference.

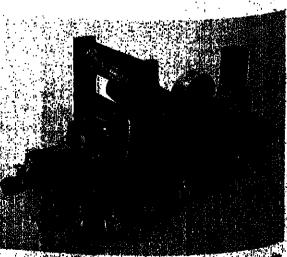
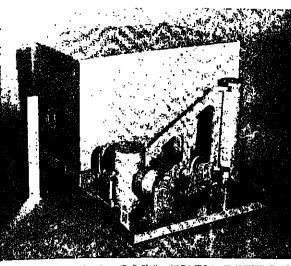


Fig. 11. Geolech Model 7505A selsmomeler, allowing illow Probalacing unit on back alde of hinge



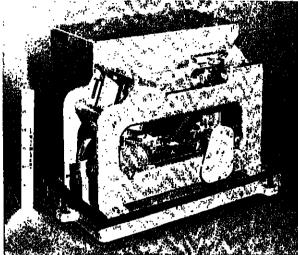


Fig. 12. Sprengnether long-period seismometers: (a) vertical component, (b) horizontal component.

During the study of this seismometer and others there was much discussion of how small a mass could be adequate. Clearly, the greater the mass, the more energy available from earth vibrations to be recorded. Also, the instrument selfnoise power was believed to be inversely proportional to the mass. Both considerations suggested that there should be a minimum acceptable mass. Wolf discussed this in 1942, Byrns in 1961, and Johnson and Matheson about the same time. With these studies and other factors in mind, the 18-kg mass of the NBS selsmometer was thought to be just adequate. Only years later did review of earlier published theory, by O. D. Starkey of Geotech, Block and Moore [1966, 1970], and the present author, establish the fact that the damping energy was the only source of thermal noise—the ultimate imit of useful sensitivity.

Of course, the total damping energy depends on the mass, so if the mass is very small, the absolute damping must be very low-effectively, the 'Q' must be very high. Also, it should be noted that the external damping power of an elecrodynamic seismometer provides the only means of registering its motion or, equivalently, transferring information outside the Instrument. The Internal damping, including coll losses, does not transfer information. This theory and supporting earlier experiments were covered in a review paper by Mel-

Earthquakes and explosions both produce seismic body and surface waves; however, explosions generate relatively weaker long-period surface waves than do earthquakes. Thus to distinguish between earthquakes and explosions, long-period seismometers are desirable in association with short-period seismometers, but experience with the DTMB Instruments discouraged development until Ewing and Press [1953], at the Lamont Geological Observatory of Columbia University, put into service a long-period vertical component seismometer that was built by Lehner & Griffith of Pasadena, California. Figure 9 shows this instrument, which was compensated for varying air buoyancy by an outrigged hollow sphere which had a volume equal to that of the seismometer's inertial mass. This instrument employed the LaCoste zero-length spring suspension, thereby emphasizing its practicality. However, the selsmometer was not shielded against air currents or insulated against temperature

The need for temperature stability and insensitivity to air currents and barometric pressure changes called for an enclosed design for production. Accordingly, Geotech provided a design with a base and an airtight heavy case of Mehanite, a cast-Iron alloy, which was clamped into a gasket around the perimeter of the base. The long-period vertical component was manufactured as Geotech Model 7505A. The associated horizontal component was Model 8700C. Both models are shown in Figure 10. The vertical component shown in Figure 11 has a balancing weight whose position can be changed by a motor drive that adjusts the mass 'rest position' to its center of travel. This model worked well at natural periods up to 15 s, but many instruments were unstable at periods greater than 20 s, chiefly because the LaCoste design was neither well understood nor well executed, and partly because of unsuspected paramagnetism of the electrical coil form, which was later corrected. These instruments were put in service late in 1962. The problems with these instruments resulted in publication of the Melton [1971] paper on the LaCoste suspension.

Sprengnether also built modern vertical and horizontal long-period seismometers, which are shown in Figure 12. In a well-protected environment these instruments serve as well as those of Geotech. In 1962, Sprengnether long-period vertical and horizontal component seismometers were installed as part of the World-Wide Seismograph System operated by the Coast and Geodetic Survey of the U.S. Department of Commerce. The vertical seismometers have a temperature compensator to adjust for gradual temperature changes, and both vertical and horizontal instruments are provided with metal covers with heaters and expanded polystyrene covers over the metal. These covers are not sealed however.

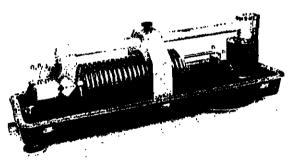


Fig. 14. Melton variable period seismometer

and $B = (8 + A^4)/8A$ As all quantities on the left side of (6.3.22) are real and positive, physical reality demands that the right side must be positive for all values of ϕ . The minimum value of $\phi^{-6} + \phi^2$ occurs at $\phi = \sqrt[8]{3}$ and is $4\sqrt[4]{3}/3$. For the problem at hand we can take ω at midband, so that $\phi = 1$. Then, substituting the angular frequencies, we find that $A^2 = 13.64$, $B^2 = 43.13$, so $4 \times 0.8^2 M/K(y/\theta)^2 = 2 + 43.13 - 13.64 = 31.49$ $y = 3.51 \theta (K/M)$ Substituting the seismometer's 10-kg mass and the galvanometer's moment of inertia 4×10^{-6} kg m s⁻², we obtain $K/M = 10^{-7}$, so that $y = 2.22 \times 10^{-3} 0$ meters Experience had shown that we could observe and record a galvanometer angular deflection of somewhat less than a microradian by using a phototube amplifier with a good power et a period of 38.7 s.

where

supply. Taking $\theta = 1 \times 10^{-6}$ rad, we have $y = 2.22 \times 10^{-9}$ m When the above calculations were made, there was little Information on the expected amplitude of microselamic noise at the longer periods. The data of Trott [1965], Savino et al. [1972], Murphy et al. [1972], and Flx [1972] were not available. These data were reviewed and collated by Melton [1976], and it is interesting to reexamine the choice of a 10kg seismometer mass with the long-period galvanometer, in light of the later information. Unfortunately, the spectral analysis presentation of a sta-

tistical sampling procedure masks the fact that at any given time the microseisms are nearly sinusoidal and mosily at one period. Similarly, earthquake waves usually have a maximum amplitude at some period that changes slowly, and it is this amplitude upon which detection depends. Therefore, we need to realize how microselams over a narrow band are translated into a statistical value taken over a long time.

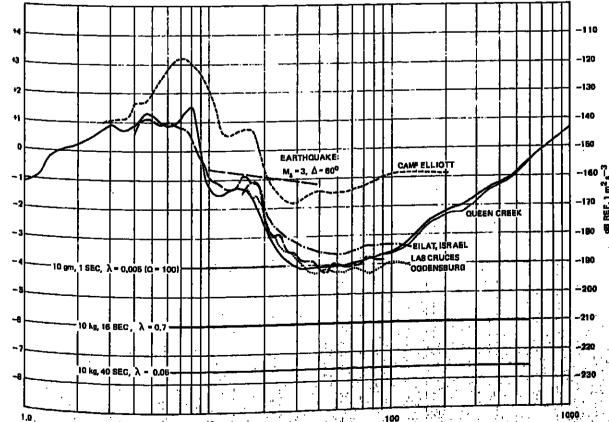


Fig. 13. Medium- and long-period spectra of earth noise plotted as squared acceleration per millihertz. The Queen Creek spectrum, for the managinal instruifler Fix [1972]; is shown with two branches, the thin line lower branch representing the noise after subtraction of the measured instru-nental roles lead to be presented by the substitution of the seasons. mental noise included in the upper branches, the thirt line lower branch representing the loads a negligible portion of the energy represented. The Camp Elliott curve, after Heubrich and MacKenzie [1966], represents data from a southern California site about 20 km from the West Coast, References for the other curves are as follows: Las Cruces, New Mexico, Troit [1965]; Ogdensburg, New Jersey, Savino et al. [1972]. lavino et al. [1972]; and Ellat, Israel, Murphy et al. [1972]. Thermal acceleration energy for several assumed selamometers is shown by the horizontal solid lines, and a proposed frequency plot of an earthquake with surface wave magnitude of 3 at 60° epicentral distance is included in order to all the surface and a proposed frequency plot of an earthquake with surface wave magnitude of 3 at 60° epicentral distance is included in order to show the relation between earthquake and noise energy.

PERIOD (seconds)

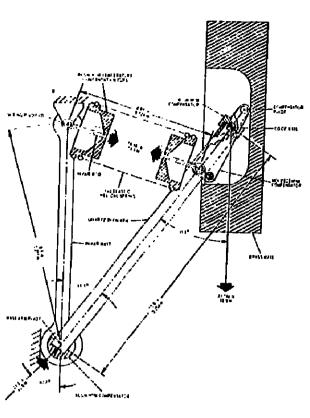


Fig. 16. Construction of La Costo suspension in one element of the

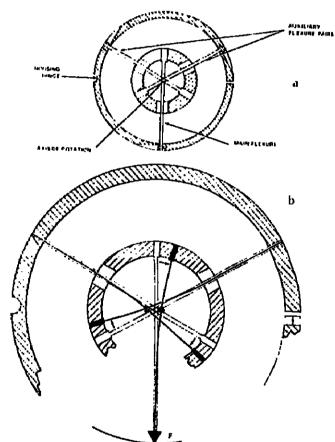


Fig. 17. (a) Basic configuration of triflexurs hinge. (b) Introduction of force couple as inner member is rotated. Forcing open the outer housing at the slit on the right produces a tension force F. As the crossing point of the flexures moves away from the central axis, the force F tends to produce further rotation. The net result is to increase the seismometer natural period.

Consider Figure 13, which is reproduced from Melton [1976], and examine the region which shows curve maxima from 12 to 18 s. This curve should be interpreted simply as picturing a high probability that nearly sinusoidal microseisms will appear in this band, and by the same token they reduce the probability of earthquake wave detection in this same band. As we cannot validly reduce any statistical value ge energy to some specific value of energy at a single frequency, we must choose a bandwidth for conversion purposes. Based on comparisons of early visual measurements of microsolsmic amplitudes to the later statislical frequency analysis, my compromise choice is one-third

Therefore, in the passband from 15 to 100 s, microselsms at 20 s or less should reduce the probability of detection over, say, a one-third-octave band centored at 17 s, 13.6 mHz. Taking an arbitrary value 1×10^{-1} (nm² s⁻⁴)/mHz, we have for one-third octave a mean square acceleration of 1.36 nm² s 4 and an rms acceleration of 1.17 nm s-2, which corresponds to an rms amplitude of 2.72 nm at 17 s or a peak-topeak amplitude about 3 times that value, or 8.15 nm

Thus, if we accept a detection amplitude value of 2.22 nm over a flat passband from 15 to 100 s, we can conclude that the seismometer-galvanometer combination considered above has a high probability of having an adequate detection; capability. However, in any real system the seismometer would be connected to the galvanometer through a resistive network that has some minimal loss, so prudence suggests that choice of a much smaller seismometer mass would not be advisable unless a galvanometer that has a lower moment of inertia were chosen also. For example, a Lehner & Griffith galvanometer Model GL-261 has a moment of inertia di 2.6 × 10⁻⁷ ka m². :

Earth Noise Studies

As late as 1958 the seismological literature disclosed very little information on the amplitude of microseisms and cultural noise relating to geology, geography, time of year, or frequency of occurrence. However, in 1949 the Naval Ordnance Laboratory (NOL), located in White Oak, Maryland, was assigned to investigate these phenomena. No instruments were available for this study, so a laboratory group under the direction of J. V. Atanasoff, later directed by Ben Snavely, undertook to build small vertical and horizontal component seismometers for field deployment. These little seismometers, designed to go down a hole, used masses of about 100 g. Most of the suspended mass of each instrument was in a flat plate centered between two fixed plates, and the combination formed part of an electrical bridge that controlled the phase of a high-frequency carrier current, which was amplified and demodulated to give the low-frequency seismic signal output. The mass/plate of the horizontal component instrument was mounted on the top end of a thin flat spring. The vertical component mass/plate was also attached to a flat spring member, but a vertical coll spring was added to offset gravity. Both components had a natural mechanical period of about 1 s. A patent issued to Atanasoff and Kolsrud in 1956 reveals the details.

These instruments employed electrostatic forces to modify their response. A controllable do potential difference between moving and fixed plates served to decrease the effective apring rate (restoring force), thus increasing the period to several seconds. Blasing this potential in favor of one or the other fixed plate served to recenter the movable plate. This recentering bias was provided by a long time-constant (~200 s) integration of the demodulated signal output, thereby reducing long-term drift. The demodulated signal output was also differentiated and fed back to provide controllable damping. The amplified signal output of each seismometer drove a galvanometer that deflected a light spot on photographic film, which was translated to provide the time axis. Also, the amplified signals were fed to Esterline-Angus chart recorders to monitor seismometer operation.

The NOL selsmographs were deployed late in 1949 and were operated by military personnel through much of 1950, serving to relate microselsms of different frequencies to different times, as oceanic storms varied conditions of generation. However, these instruments were critical in adjustment, both mechanically and electrically, and not well suited to unattended operation. Also, their locations were restricted because they had power supplies that required connection to a commercial power line.

As experience was gained in siting seismometers for earth noise studies, and as more observatories were set up at numerous geologic locations, the construction of seismometer vaults was found to be important. Finally came the realization that even a concrete vault beneath the surface required a means of entrance which, if part of the structure, coupled the entire vauil to the surface of the earth, thereby transmitting surface disturbances to the seismometer. Therefore, consideration was given to designing seismometers that could be put down a deep hole and adjusted, as necessary, by remote

Accordingly, efforts to measure local earth disturbances as a function of depth were begun under a contract with United Electro Dynamics Corp. (UED) to put a seismometer at different depths in some abandoned oil well hole and to measure the noise at each depth in comparison with the noise at the surface. Shell's Government No. 1 well near DuBois in Fremont County, Wyoming, was chosen for this study, which began in late 1958. Many troubles were experienced with the instrument sent downhole, and the mud level sank continually. Only in 1960 were results obtained that seemed to indicate the expected reduction of noise as compared with standard instruments installed on the surface near the well. The well study was terminated in April 1960, but John Woolson of UED made further noise measurements for various geological surface conditions and sites for a number of months thereafter and on into mld-1961. Also, there were several attempts to correlate microselsms between sites separated by about a half kilometer or more. Spectral analysis was done by analog methods, by moving a filter band over a repeated sample of the noise on magnetic tape, this at higher

tape speed in order to bring the signals into the audio band. The well measurements were only the forerunners of later studies too extensive to discuss at length. In mid-1962 a variable reluctance seismometer, based on Benioff's design, was

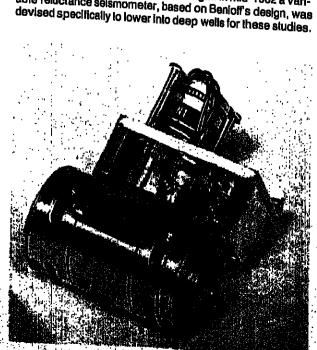


Fig. 18. Triflexure hinge and motor assembly. The reversible molor serves to adjust the tension F, shown in Figure 17; thereby con-

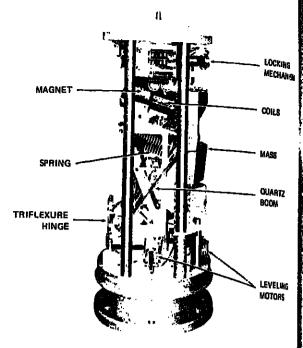
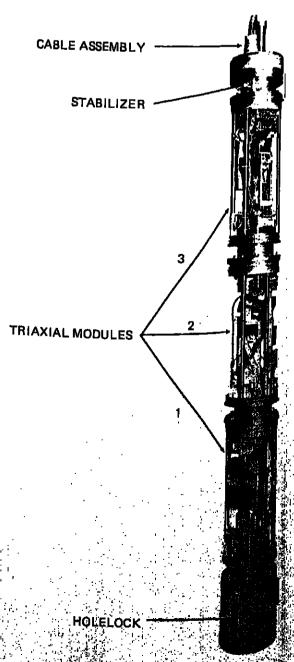


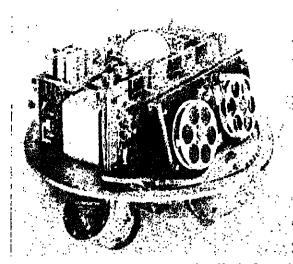
Fig. 19. Single module of the triaxial seismometer

This instrument had a 100-kg mass and provided sufficient electrical output to ensure adequate sensitivity for measur a very low noise field at great depths. The first well surveyed Magnolia's Trigg No. 1, was located in the northeast part of Tarrant County, Texas, on the present site of the Dallas/For Worth airport. The well was about 3000 m deep, bottomedia

The Variable Period Seismometer—Its Concept and

In 1959 the author suggested, with a construction sketch, that a variable period seismometer be devised for use by any selsmologist for his particular interest. The concept was to provide the critical parts unassembled, to be put together by the individual seismologist. However, funds were unavailable until later, when discussions of the atomic test ban took place and the USSR representatives offered some of their selsmometers for comparison. As there were no comparable American seismometers available, funds were provided, and the Melton seismometer (Figure 14) was created. In this see mometer the 5-kg mass can be moved to or from the hinge. and the spring tension can be adjusted by stretching or relaing the spring. A steel tape attached to the spring is wounder or off a drum through a worm and gear mechanism for this adjustment. The natural period is variable from 0.5 to 7 s. while the electrical circuit resistance required for damping? mains nearly constant. Hamilton and Stephens [1962] ## tion that this instrument was installed at the Dallas Seismo-





nograph developed for the Scripps In-



Fig. 22. Russian geophysical prospecting seismometer showing etrical triaxial arrangement of three of its sensors.

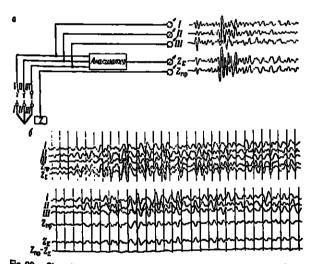


Fig. 23. Signal traces from the four sensors of the Gal'perin sels-

logical Observatory at Southern Methodist University (SMU) to provide a flat "velocity" response over the period range

The Symmetrical Triaxial Configuration

Emphasis on adequate identification of long-period earthquake waves influenced the next development. The Instrument was described and patented as an 'Angular Composite Seismometer, but it became known as the 'Symmetrical Triaxial Seismometer.' In such an instrument the Orthogonal directions of response form equal angles of about 55° with the vertical. These orthogonal directions per sensing acceleration components that can be rotated al-Bebraically to the conventional horizontal and vertical direclions, provided the physical orientation of the instrument is known. The advantage of such an arrangement is that all three spring-mass systems are designed identically, giving greater assurance of matching characteristics. Also, as the arm carrying each mass is within about 35° of the vertical, the horizontal dimension can be less. Then stacking the three elements vertically permits a slim design, suited to putting

My notes show that this composite seismometer was described to an associate on March 7, 1960. The ultimate mechanical chanical design by Burnard Kirkpatrick of Geotech was underway in 1966, and an array of these instruments was being installed near Fairbanks, Alaska, in late 1968. The patent Was filed in 1963 and issued December 7, 1965. The individual element masses were 10 kg because we had no assurance at the time that a lighter mass would be adequate. Each LaCoste suspension was designed and adjusted to the "infinite period position. Then the period was adjusted by changing the tension on a special triflexure hinge by way of a motor drive. Figure 15 diagrams the LaCoste suspension.
The angle 5 is zero for 'Infinite period,' Figure 16 shows the basic control of the strains debasic construction of one element. Figure 17 illustrates design principles of the triflexure hinge: Figure 18 shows the hinge and motor assembly. A more complete description is given by Melton and Kirkpatrick [1970]. Weinstein [1966]

discusses hinges of this general type as 'flexure pivot bear-

Figures 19 and 20 show a single module and an uncased assembly of three modules with holelock underneath and a stabilizing device at the top. These instruments showed greatly reduced response to local surface disturbances caused by wind and atmospheric pressure variations, even though in some installations the depth was much less than planned, because of drilling problems.

The symmetrical triaxial configuration was incorporated into an ocean bottom seismograph developed for the Scripps Institution of Oceanography by Earth Sciences Division, Teledyne industries. Figure 21 shows the uncased assem-

The symmetrical triaxial principle has also found its way into geophysical prospecting. Gal'perin [1977] has published a book which describes a polarization scheme of recording all types of waves simultaneously. In this scheme, four sensors are used. Three of them are oriented triaxially, as suggested in Figure 22. A fourth sensor responds as an independent vertical component. Figure 23 shows signal traces from these elements. Trace Z_x is evidently the effective vertical formed by direct summation of the triaxial component signals, while Z_{n} is the independent vertical signal. The Z_{n} - Z_{Σ} trace, if quiet, indicates a true amplitude match of the vertical component signal amplitude to the signal composed of the triaxial sensors and implies proper calibration of all sensor

Principles and Practices for a Radically Different Seismometer Design

Even as the symmetrical triaxial was being developed and put in service, a new concept of mass-thermal noise relationship was evolving. The realization that the thermal noise of a seismometer depended on its damping losses (rather than on its mass) suggested that a much lower mass and smaller seismometer could be devised, provided that amplifiers could compensate for reduced seismometer outputs. Briefly stated, the thermal noise (force) of a periodic system, electrical or mechanical, resides in its lossy elements. The system oscillations indicate the presence of some force, including thermai noise, but the amplitude of mass (or spring) oscillation is only a measure of energy, not the energy source itself.

O. D. Starkey of Geotech reviewed the work of McCombie [1953], Milatz and van Zolingen | 1953], and Milatz et al. 1953], and by 1966 had composed a long handwritten treat-Ise which included a 31-page section on Active Damping in Seismometer-Amplifier Combinations.' Block and Moore [1966, 1970] showed how active damping could be applied in designing an accelerometer, and I became fully aware of the principles in April 1970 when called upon as a consultant to evaluate the Block-Moore instrument. Essentially, the proposal was to provide a very small quartz seismometer with the desired damping—say, 0.7 critical—by applying negative

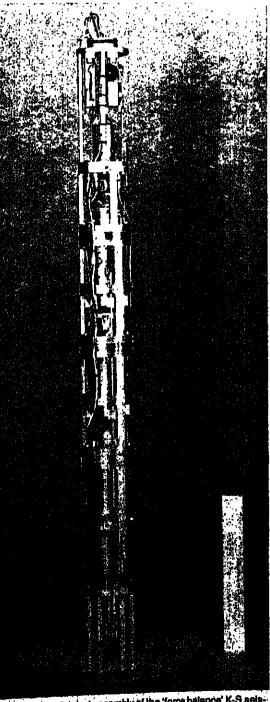


Fig. 24: Mechanical assembly of the force balance K-9 setsmometers, Geotech Model 38000, later known as the SRO selsmograph system. ...

feedback force to the mass, proportional to velocity, rather than using loss damping of any nature. The little mass would be part of a capacitance bridge modulator to provide an electrical output as the mass moved. A general discussion of this arrangement follows.

We have noted that the electrical load of a conventional electrodynamic seismometer provides the information output. So, if the load is eliminated, means must be devised to sense mass movement. This is feasible with a properly designed modulation scheme, which in itself produces negligible mechanical reaction noise. A modulator is generally understood to be a device by which a low-frequency signal modifies a high-frequency carrier. The modulated carrier can then be amplified as desired, and a demodulator can recover the amplified low-frequency component. In this manner one avoids so-called 'one-over-f' noise, a characteristic noise injected by all active devices that control do power (that is, ampliflers) and which increases dramatically at periods greater than 10 s. Figure 31 of part 2, in the section on carrier amplifiers, illustrates this with factual data.

Application of the above principles eventually made possible the development in 1970 of a more useful 'downhole' seismometer-the Geotech Model 36000 seismometerknown locally as the 'K-S Selsmometer,' after its designers Burnard Kirkpatrick and O. D. Starkey. This seismometer can be lowered inside a 7-inch (outside diameter) 20 lb/ft API



Fig. 25. Cased assembly of the Model 36000 selamometer, including downhole electronic components, ready to be lowered into a

casing. The uncased mechanical assembly appears in Figure 24. In order, from the bottom upward, are shown the two horizontal components, the vertical component, and the air pulse mechanism. An air pulse is fed to a ball-and-socket joint at the top of each component case to free the joint momentarily and allow the case to seek a vertical position. This is necessary because, in general, the hole is not vertical. Figure 25 shows a cased assembly, including electronic components, ready to go down a hole. These setsmometers were put in service in 1975 as the Seismic Research Observatory (SRO) seismograph system, described by Peterson and Orsini [1976], Peterson et al. [1976],

Bibliography

Atanasoff, J. V., and E. R. Kolsrud, Low-frequency vibration detection device, U. S. Palent 2,739,297, 1956.

Benioff, H., A new vertical selemograph, Bull. Selsmol. Soc. Am., 22, 155-169, 1932.



Uncased assembly of the three modules of the hard-ster, troogs by With a holelock medianism below and sec

Benioff, H., A reluctance seismograph for ultra long period waves, paper presented at Assemblée de Toronto, Assoc. de Seismol. et de Phys. de L'Interieur de la Terre, Sept. 1957. Benioff, H. and F. Press. New results from long period seismographs, paper presented at Assemblée de Toronto, Assoc. de

Seismol, et de Phys. de L'Interleur de la Terre, Sept. 1957. Block, B., and R. D. Moore, Measurements in the earth mode frequency range by an electrostatic sensing and feedback gravimeter, J. Geophys. Ros., 71, (18) 4361-4375, 1966.

Block, B., and R. D. Moore, Tidal to seismic frequency investigations with a quartz accelerometer of new geometry, J. Geophys. Res., 75 (18), 1493-1505, 1970. Byrne, C. J., instrument noise in seismometers, Bull. Seismol. Soc.

Am., 51, 69-84, 1961.

Dewey, J., and P. Byerly, The early history of selamometry (to 1900), Bull. Selamol. Soc. Am., 59 (1), 183-227, 1969. Ewing, M., and F. Press, Further study of atmospheric pressure fluctuations recorded on seismographs, Eos Trans. AGU, 34, 95-100,

Fix, J. E., Ambient earth motion in the period range from 0.1 to 2560 sec., Bull. Seismol. Soc. Am., 62, 1753-1760, 1972. Galitzin, B., Zur methodik der seismometrischen beobach izv. Akad. Nauk. SSSR, 5 (19), 30-31, 1903. (Libr. Cong. Call No.

AS262, S34.) Gol perin, E. I., Polyarizatsionnyl Metod Salsmicheskikh issledo-vanii (Polarization Method of Selsmic Prospecting), Nedra Press, Moskow, 1977.

Hamilton, J. H., and E. Stephens, Jr., New developments in sels-mological instrumentation, *Tech. Rep. 62-1*, 36 pp., The Geolech. Corp., Garland, Tex. 1962.

Haubrich, R. A., and G. S. MacKenzie, Earth noise, 5 to 500 millicycles per second, J. Geophys. Res., 70 (6), 1429-1440, 1985. La Coste, L. J. B., and A. Romberg, Force measuring device, U. S. Patent 2,293,437, 1942.

McCombie, C. W., Fluctuation theory in physical measurements, Rep. Progr. Phys., 16, 268–320, 1953. Molton, B. S., and P. R. Karr, Polarity coincidence scheme for re-

voaling signal coherence, Geophysics 22, 553-584, 1957. Melton, Ben S., The La Coste susponsion—principles and practice, Geophys J. R. Astron. Soc., 22, 521-543, 1971.

Molton, B. S., The sensitivity and dynamic range of inertial seismo-graphs, Rev. Geophys. Space Phys., 14, 93- 118, 1976. Melton, B. S., and D. P. Johnson, Inertial seismograph design—Lim-itations in principle and practice, Proc. Inst. Radio. Eng., 50, 2328-2339, 1962.

Melton, B. S., and B. M. Kirkpatrick, The symmetrical triaxial seismometer—lis design for application to long-period seismometry. Bull. Seismol. Soc. Am., 60, 717-739, 1970. Milatz, J. M. W., and J. J. van Zolingen, The Brownlan motion of

electromoters, Physica, 19, 181-194, 1953. Milatz, J. M. W., J. J. van Zolingen, and B. B. van Iperen, The reduction of Brownlen motion of electrometers. Physica, 19, 197–207,

Murphy, A. J., J. Savino, J. M. W. Rynn, G. L. Choy, and K. McCarny, Observations of long-period (10-100 sec) selsmic noise at several worldwide locations, J. Geophys. Res., 77 (26), 5042-5049, 1972,

Peterson, J., and N. A. Orsini, Seismic Research Observatories: Upgrading the worldwide seismic data network. Eos Trans. AGU, 57,

Peterson, J., H. M. Butter, L. G. Holcomb, and C. R. Hutt, The Seismic Research Observatory, Bull. Seismol. Soc. Am., 66, 2049-Savino, J., K. McCamy, and G. Hade, Structures in earth noise

beyond twenty seconds, A window for earthquakes, Bull. Selsmol. Soc. Am., 62, 141-176, 1972.

Trott, W., Investigation of noise in long-period seismographs, *Tech. Rep.* 65–91, Teledyne Geotech, Garland, Texas, 1965.
Weinstein, W. D., Flexure pivot bearings, *Mach. Des.*, 37, 150–157, June 10, and 136–145, July 8, 1965.

Wenner, F., A new seismometer equipped for electromagnetic damping and electromagnetic and optical magnification, J. Res. Nat. Bur. Stand. (U.S.), 2, 963-999, 1929.

Wolf, A., The limiting sensitivity of seismic detectors, Geophysics, 7,



Ben S. Mellon, from Dallas, Texas, received the B.S. degree in electrical engineering from Rico University, Houston, in 1925. Following a student engineering course at the General Electric Company and a short time as engineer with the Gulf States Utilities Company, Port Arthur and Beaumont, Toxos, he was employed by the General Exploration Company, Houston, to do research and development work in electromagnetic prospecting for oil, during the years 1928 to 1930. Late in 1930 he entered the field of seismograph prospecting with Geophysical Service, Inc., Dallas, and except for a short period, remained in that work until 1942, becoming associated with the National Geophysical Company, Dallas, from 1937 until April 1942. That year he joined the staff of the Applied Physics Laboratory. The Johns Hopkins University, Silver Spring, Maryland, as a radio engineer on the proximity-fuse project. Leter he was involved in de-vergement of optical and other methods for examining supersonic flow in connection with ramjet flight.

in December 1948 he accepted appointment as a geophysicial with the U.S. Air Force, in connection with the program to detect and identify underground nuclear explosions. Upon retirement from this Air Force program in 1965, he became an independent consultant.

Melton is a charter member of the Society of Exploration Geophysicists, a senior member of the institute of Electrical and Electronic Engineers, and a member of the American Geophysical Union and the Seismological Society of America. He is a registered professional

News

NSF Losing Earth Sciences Research Funds

The Earth Sciences Division (EAR) of the National Science Foundation (NSF) faces a diminishing financial base from which to award grants for research, while the proposal pressure increases. Robin Brett, director of the division stated, 'Now that the Ocean Drilling Division has become a separate entity [within the Foundation] the Division of Earth Sciences has no major facility, and with the exception of COCORP, at \$2.8 million per year, we are a small science division, consisting of four programs—geology, geophysics, geochemistry, and petrology."

Brett noted, however, that the field of earth sciences research, which the NSF attempts to support, has grown rapidly in the past decade. 'Growth (in terms of people employed in the fleid) is predicted to increase markedly, as the following quotation from Science and Engineering Education for the 1980s and Beyond (NSF publication, 1980) at-

"Among the sciences, growth (between 1978 and 1990) is put at 40% for psychologists, geologists, statisticians, and economists. Occupations with projected slow growth include atmospheric scientists, physicists and astronomers, and mathematicians, all of which are projected at 10 per-

'The average grant has decreased in dollar value rapidly

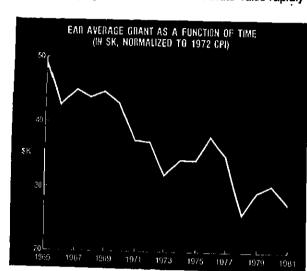


Fig. 1. Plot of the average annual grant made by the Earth Sciences Division (EAR) of the National Science Foundation as a function of time (in \$K normalized to 1972 CPI).

TOTAL NUMBER OF PROPOSALS RECEIVED BY EAR AS A FUNCTION OF TIME 1969 1971 1973 1975 1977 1979

Fig. 2. Total number of proposals received by the Earth Sciences Division (EAR) of the National Science Foundation as a

during the past decade or so, Brett said. In 1965 the average grant was close to \$50,000.00 in the earth sciences. (See Figure 1.) In 1981 the average annual grant is about \$27,000.00. Inflation has caused the decrease, while the ratio of the budgeted dollar per investigator has remained less than level, and while the cost of research has increased; instrumentation is not cheap: one modern mass spectrometer laboratory costs \$400,000.00, enough to equip ten earth science departments thirty years agoi

At the same time, the portions of grants allocated to be spent on investigator's salaries and institutional overhead have increased.

A major problem at the NSF Earth Sciences Division to day is the enormous number of research proposals. It is an almost impossible task to process the proposals, much less fund them. The NSF visitor today will see 10-15-fi stacks of proposals being moved about, warehouse slyle, by loklift trucks. A current joke at the NSF is that assistant program managers are being hired just to enable the divisions to hire secretaries to handle the load of proposals. Congress has repeatedly cut the staff and operation of NSF. but the work load continues to increase. The number of proposals received by the NSF Earth Sciences Division's increasing by an exponential function (see Figure 2).—P.F.

HEAO-2 Completes Flight Mission

The second High-Energy Astronomy Observatory (HEAO 2) has expended its control gas supply, completing its flight

The spacecraft was launched Nov. 13, 1978. It carried the world's largest focusing X ray telescope and an array of imaging and analyzing astronomy instruments. During its extra-long lifetime, it performed thousands of studies of Xray-emilting stars, supernova remnants, galaxies, and qua-

HEAO 2 is one of a family of three highly successful scientific satellites managed by NASA's Marshall Space Flight Center, Huntsville, Ala. With 2 years and 5 months of operatlons, HEAO 2, like its predecessor HEAO 1, performed more than twice as long as its design called for-a feat expected to be equaled by the third observatory, which is still

Although it will take years for participating astronomers to analyze completely all the data they received, important data have already been obtained about the X ray output of normal stars, the composition of supernova remnants, the distribution of mass in galaxies and clusters of galaxies,

and the origin of the extragalactic X ray background. The spacecraft was operating extremely well, Marshall Center officials reported, when it expended the last of its reaction control gas Saturday afternoon, April 25, and could no longer maintain its pointing attitude. Spacecraft and instrument engineering tests were performed until the batteries were discharged, and on a subsequent orbit Sunday morning, when the solar panels were receiving sunlight, all systems were powered down. Reentry and burnup are expected to take place next year.—PMB [Source: NASA] 88

Petroleum Research Grants

Five earth sciences grants are available through the American Chemical Society's Petroleum Research Fund (PRF). These grants are intended to assist advanced scientific education and fundamental research in the "petroleum field," which may include any field of pure science which . . . may afford a basis for subsequent research directly connected with the petroleum field, according to Jusiln W. Collat, PRF program administrator. The grants are divided into three categories, Collat said.

The first, called type AC, generally supports graduate students or postdoctoral fellows. Awards may be up to \$15,000 per year for a maximum of 3 years. The second, type B, is for faculty research with undergraduate students in adademic departments which do not offer a Ph.D. degree. The maximum award is \$6500 annually for 2 years. And last, a special starter grant program is available lonbeginning faculty investigators. These grants consist of

\$10,000 for 2 years, Collat said, and are limited to faculty members in the first 3 years of their first faculty appointment. These faculty members cannot have any major support of their research, except for that provided by their inst

Proposals, accepted throughout the year, are evaluated by the 24-member PRF Advisory Board.

For additional Information, contact Collat, The Petroleum Research Fund, American Chemical Society, 1155 16th Street, N.W., Washington, D.C. 20036 (telephone: 202872-4481).—*BTR* 88

Geophysical Event

Pagan Volcano, Mariana Islands, Western Pacific Ocean (18.13°N, 145.80°E). All times are local (GMT + 10 h) strong explosive eruption from North Pagan, the larger of the two stratovolcanos that form the Pagan volcano conplex, began on May 15. While reporting strong felt selsmi ity on the Island, radio operator Pedro Castro suddenly all nounced at 0915 that the volcano was erupting. Commun cation was then cut off. An infrared image returned from the Japanese geostationary weather satellite at 1000 showed very bright circular cloud about 80 km in diameter over the volcano. The cloud spread SE at about 70 km/h, and by 1600 its maximum height was estimated at 13.5 km iron satellite imagery. Weakening of activity was evident on the Image returned at 1900, and on the next Image, at 2200, feeding of the eruption cloud had stopped, with the provimai end of the cloud located about 120 km SE of the voke no. No additional activity has been detected on the sales images, but by 0400 the next morning, remnants of the plume had reached 10°N and 155°E.

Alrcraft attempting to land on Pagan Island were present attempting to land on Pagan Island were present and from doing so by the eruption. At 1235, pilots reported mushroom cloud over the Island and ashfall over its not ern and eastern ends. Ash falls were also reported from Agrigan Island, 105 km to the NW. Additional pilot reported at 1410 indicated that the eruption was intensifying at the cloud had reached more than 7 km situate. Unlikely the cloud had reached more than 7-km altitude Unlied Press International reports that aircraft craws fiying plant island at two different (but unspecified) times say air island at two different (but unspecified) times say air island at two different (but unspecified). to 10.5 and 18 km. The U.S. Navy reported lava 1000 down the NE and NW flanks into the sea and abo down the SW flank to within 1 km of the island's village 1/2 km of the airstrip. However, the aircraft instruments measured surface temperature of the lava at 200 fall

The Japanese merchant ship Hoyo Maru rescued persons on Pagan Island early May 16 None of the dents were injured;

The U.S.L.Geological Survey sent a three man lean the Hawallan Volcant Observatory to Pagan Island Miles

Information contacts: Frank Smigleiski, NOAA/National Environmental Satellite Service, Synoptic Analysis Branch. S/OP33, Camp Springs, Maryland 20233.

Gus Telegadas, Room 617, NOAA/Air Resources Laboratory, Silver Spring, Maryland 20910.
Robert Tilling, U.S. Geological Survey, Stop 906, Nation-

al Center, Reston, Virginia 22092. U.S. Department of Defense. United Press International. 35

Geophysicists

Daniel P. Beard was appointed executive director of the Renewable Natural Resources Foundation, effective May 1 He succeeds Gordon Fredine, who has retired.

Farouk El-Baz, of the Smithsonian's National Air and Space Museum, was presented with the Arab Republic of Egypt 'Order of Merit-First Class' by President Anwar Sadat El-Baz cited for his contributions to space geology, advises Sadat on scientific matters. The presentation was made at the First Science Celebration Day in Cairo, on



James F. Hays will succeed Raymond Siever as chairman of the Department of Geological Sciences at Harvard University as of July 1. Slever will remain on the depart-

Peter J. Schreuder has been appointed a vice president at Geraghty & Miller, Inc., consulting groundwater geologlats and hydrologists. He is the director of the company's Tampa, Fla., and Baton Rouge, La., offices.



Kenneth M. Watson was appointed director of the Marine Physical Laboratory at Scripps Institution of Oceanography He comes to Scripps after serving for more than 20 years as a professor of physics and researcher at the University of California at Berkeley and at the Lawrence Berkeley Laboratory. Watson succeeds Fred N. Speiss, who now heads the University of California's Institute of Marine Resources. (Photo courtesy of Scripps)

Geophysicist Obituaries

The following AGU members are recently deceased: Joseph M. Caldwell, 69, on December 21, 1980. Joined William M. Chappie, 46. on February 18, 1981. Joined In

James E. Gill, 80, in January, 1981. Life member, joined in 1947.

James Gilluly, 84, on December 31, 1980. Life Fellow, joined in 1934. Nathan M. Newmark, 70, on January 25, 1981. Fellow,

loined in 1962. Anthony J. Polos, 71, in June, 1980. Life member, joined in

Ernest Tillotson, 77, on March 29, 1981. Life member, joined in 1947.

George D. Whitmore, 82, on February 9, 1981. Life member, joined in 1946.

New Publications

Early Diagenesis, A Theoretical Approach

R.A. Berner, Princeton Ser. in Geochem., Princeton University Press, Princeton, New Jersey, xii + 241 pp., 1980, \$25 (cloth), \$9.50 (paper).

Reviewed by Donald L. Graf

In the last 15 years the author has carried out field and laboratory studies of solid importance to an impressive variely of areas in sedimentary geochemistry. This activity, coupled with his lively curiosity about established theoretical concepts in other sciences that can be brought to bear on geochemical problems, has yielded numerous scientific articles and an earlier book, in 1971. We encounter most of the theoretical aspects of these publications again here, leavened with additional calculations, more recent literature citations, and additional insights about applicability obtained

during the intervening years of teaching and research. The transport equations that form the theoretical core of the book should be familiar to chemical engineers, hydrologists, petroleum reservoir engineers, and physical oceanographers. Most of the applications are to ocean sediments. The book is divided into a theoretical section, in which suitable equations are developed to describe the physical, biological, and chemical processes encountered in diagenesis, and a discussion of applications to marine sediments of the continental margins, deep-sea sediments, and nonmarine sediments. However, because much of the literature cited in the latter section involves tests of mathematical models, the book is in practice an interplay throughout between equations and sets of data, with interspersed excerpts from Peripheral fields (e.g., equilibrium thermodynamics, ion exchange, rate laws, microbial reactions, nucleation, and crystal growth).

Even though some useful mathematical simplifications result from considering only the first few hundred meters of sediment, the problems considered are still very complex. The common-sense approach used by Berner and his fellow modelmakers is first to define theoretical relationships with reasonable but not ultimate precision, then to seek plausible ways of simplifying these expressions for particular problem. lar problems, next to accumulate a number of tests of the simplified expressions against particular sets of data, and then to fine-tune back and forth until models are obtained that, we hope, are uniquely successful in describing a parlicular geochemical environment.

The book is a veritable encyclopedia of simplifying assumptions (11 are cited in developing one model for calcitim carbonate distribution on the floor of the deep ocean) Which raises problems in comparing results from different Workers with slightly different notions of optimum simplificaton. The lacility with which physical units are redefined is a little unsettling, e.g., because bioturbation is sometimes lumped within the diffusion term in modeling, it emerges (0. 31) as a category of diffusion. Dispersion is another category ny (p. 31), which should interest hydrologists, who have

made molecular diffusion into chemical dispersion. A blessing of complex natural systems is that they afford

safety valves for models that do not quite fit-aragonite dissolving in the middle of your calcite-dissolution study area, ions poisoning the surface of your mineral so that it doesn't follow an Ideal rate law in dissolving (certainly a demonstrated effect in some systems). One could, finally, list some misleading statements in the highly condensed summaries about peripheral scientific areas.

However, none of these concerns does serious damage to the central business of modelmaking. Recent efforts that have been able to use several different kinds of measurements are particularly impressive, e.g., Aller's lateral-diffusion model for predicting ammonia distributon in the bioturbated zone and Emerson and Widmer's treatment of vivianite precipitation in Lake Greifensee sediments. The contributions of stable- and radioactive-Isolopic measurements are underrepresented.

This is a sprightly tour through the library and computer room of a country manor where the air is filled with the music of Ravel and with jests about sedimentologists and whales. Take the lour by all means, and come back again after the new wings are built.

Donald L. Graf is a member of the Department of Geology of the University of Illinois at Urbana-Champaign.

Light Scattering by Irregularly Shaped Particles

D. W. Schuerman (Ed.), Plenum, New York, x + 334 pp.,

Reviewed by E. Raschke

groups:

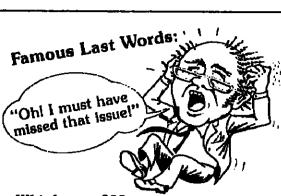
This book contains the text of two introductory papers and extended abstracts of 35 contributed papers which were presented during the International Workshop on Light Scattering by Irregularly Shaped Particles (June 5-7, 1979, State University of New York at Albany, New York). The purpose of this workshop was to review the state of understanding and the modeling of the scattering of electromagnetic radiation by irregularly shaped particles and to compare it with the first-order solutions which usually are based on equivalent spherical particles.

The field of application is extremely wide. It reaches from interpretations of stellar atmospheres, interplanetary dusts, and atmospheric aerosols to the observation of plankton and other suspended materials in the oceans with remote sensing methods.

The papers of this workshop did not cover all subjects. In the introduction, D. Deirmendijan, a meteorologist, lavored the empirical approach (i.e., in situ measurements and ad-

justments to equivalent particles). J. Majo Greenberg, how-ever, recommended extensive basic research of the physical processes involved in scattering of light by irregularly shaped particles; thus, the particle shape must be known and remote sensing techniques should use all means to exploit the information content carried by the acattered light.

The other 35 papers have been gathered into 6 sub-



Which one ???

• Was it the 'special' JGR issue on Saturn?

 Or the Radio Science papers on Optical Communications? *• The papers on SAR imaging of Ocean Waves?

• The Evolution of the Atmospheric Ozone?

• Occon Introplate Earthquakes?

Which issues of the American Geophysical Union journals have you mised because your subscription expeed or you neglected to subscribe?

We'd like to change those famous last words so that you won't miss a thing.

To subscribe or report a subscription problem Call toll free 800-424-2488.

Tell Your Colleagues This Week -Not Next Month

Place advertisements and announcements in EOS, the weekly newspaper of geophysics, and reach over 15,000 geophysicists worldwide.

Communicate the dynamics of special meetings, workshops, instrumentations, available publications, call for papers, and other pertinent ormation for your colleagues.

For low advertising rates and easy-to-meet copy deadlines, direct inquiries to:

> Robin E. Little Advertising Coordinator

800-424-2488. Back cover advertising space available.

1. User needs: In four papers are discussed the remote sensing of ice clouds, lidar visibility measurements, and several applications. Here, no contribution has been made from oceanography and astronomy.

2. Particle descriptions: Five papers describe exhaustively the shape of raindrops and ice crystals, and of aerosols from various regions. Here, again, the subject should have been extended to the other fields of applications, oceanography, and astronomy

3. Theoretical methods: Fourteen papers discuss various ways to compute the scattering by particles of various shapes. All contributions cover the subject in great depth, allowing the reader to gain an overview.

4. Experimental methods: Ten papers were presented during this session. In several of them, microwave analog experiments are described, where the extinction of single 'analog' particles is directly measured. The methodology of in situ measurements (i.e., measurements of the extinction properties of a 'volume of air') has not changed, but the technology has improved considerably. Almost all authors recommended without detailed discussion that measurements be made of as many components of the scattering matrix as possible. This chapter alone deals with the scattering by biological particles.

5. Inversion and information content: Only two papers were devoted to this subject, since even for simpler problems of scattering by pure spherical particles it is yet relalively unexplored. In one paper the size of the scatterer is inferred from polarization measurements, an attractive tool which is seldom used. In the other paper a comparison is made between irregularly shaped and spherical particles, using laser and direct solar radiation measurements. The conclusion is that nonspherical particles in the atmosphere may be considered as equivalent spheres without serious

Although many abstracts are rather short and contain only limited information, this book can be considered as an extremely helpful tool for all those research groups and individuals who are engaged in remote sensing of particle properties and quantities, either when the particles are imbedded in another medium (gases or water) or entirely free in deep space. I recommend open publications of such proceedings, because it allows the worldwide community to participate in discussions of extreme importance to their research. Expected future restrictions on travel funds will even force such means of scientific communications. A papérback version would seem adequate and less expensive than this book.

The organizers of this meeting should be encouraged to attempt another one, but it should include a much wider field of scientific research and broader international participation than they could assemble at this workshop.

E. Raschke is with the Institute for Geophysik and Me teorolog, University of Cologne, Kain, West Germany."



. 4.1

"An extraordinary publishing event." *

Quantitative Seismology Theory and Methods

Volumes I and II

Keliti Aki Massachusetts Institute of Technology

Paul G. Richards Columbia University

"This truly exquisite text/monograph provides advanced students and professionals with a wonderfully detailed and comprehensive but lucid account of physical, mathematical and instrumentational principles which lie at the quantitative heart of modern seismology. . . . Hard to imagine any respect in which the book could be improved upon, whether in the writing or the production."

-Sci Tech Book News*

CONTENTS

Preface/Introduction

Basic Theorems in Dynamic Elasticity Representation of Scientle Sources Elastic Waves from a Point Dislocation Source Plane Waves in Homogeneous Media and Their Reflection and Transmission at a Plane Boundary Reflection and Retraction of Spherical Waves;

Jamb's Problem Surface Waves in a Vertically Heterogeneous

Free Oscillations of the Earth hody Waves in Media with Depth-dependent Properties

Principles of Seismometry

Appendix 1: Glossary of Waves Appendix 2: Definition of Magnitudes Bibliography/Index

1980, 575 pages, 109 illustrations hardbound: 1058 \$37.95

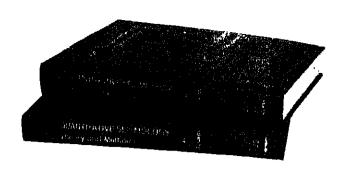
Volume II CONTENTS

Preface/Introduction Analysis of Seismological Data

Inverse Problems in Seismology Seismic Waves in Three-dimensionally Inhomogeneous Media The Seismic Source: Kinematics The Seismic Source: Dynamics

Hibliography/inclex

1980, 389 pages, 116 illustrations hardbound: 1059 \$37.95



Special 15% discount for readers of EOS

Ouantitative Seismology

Theory and Methods Volumes I and II

Please send me the following copies of Quantitative Seismology at \$32.25 for each volume with this coupon, a savings of \$5.70 per copy.

____copies, Volume I ____ copies, Volume II

Guarantee: Examine Quantitative Seismology for fourteen days. If for any reason you are not satisfied, you may return it for a full and prompt refund.

Name	
Address	
City/State	Zip

☐ I enclose payment with order. (California residents add appropriate sales tax.)

VISA/BankAmericard Master Charge.

Account Number ____

Expiration Date _

(All credit card orders must be signed.)

W. H. Freeman and Company 660 Market Street, San Francisco, CA 9410-i

Classified

EOS offers classified space for Positions Available, Positions Wanted, and Services, Supplies, Courses, and Announcements. There ads. Any type that is not publisher's choice is charged for at display rates. EOS is published weekly on Tuesday. Ads must be received in writing on Monday 1 week prior to the date of the

Reples to ads with box numbers should be addressed to: Box, American Geophysical Union, 2000 Florida Avenue, N.W., Washington,

POSITIONS WANTED 1-5 limes-\$1.00, 6-11 limes-\$0.75. 12-26 times ~\$0.55

POSITIONS AVAILABLE Rates per line 1-5 times-\$2 00, 6-11 times-\$1.60, 12-26 times - \$1.40

SERVICES, SUPPLIES, COURSES. AND ANNOUNCEMENTS 1-5 limes - \$2.50, 6-11 hmes - \$1.95.

STUDENT OPPORTUNITIES For special rates, query Robin Little, 800-424-2488

POSITIONS AVAILABLE

Research Seismologis L'Eolid Earth Geophysias. ENSCO, Inc. in Springfield, Virginia is seeking a Program Manager/Research Seamplogist to support an expanding program in solid earth geo-physics. Research areas will include seagmic network data processing associated with the detection identification and location of natural and mun-made seismic sources: sarthquake characterization and source mechanism studies; explosion source char-acterization; and empirical studies using near field and far field seismic data. Experience in theoretical and observational seismology at regional and tele-seismic distances, is highly desirable. Experience, seismology is highly degrable, however, M.S. level with experience in saringuate and explosion selemology will be considered. Salary and behelf is are extremely compelitive. Resumes along with ealary requirements should be submitted to the Personner Denariment at the address below, Attention Code SAS, ENSCO. Inc., 5408-A Port Royal Road.

Springlield, VA 22:151.
Equal employment opportunity/AAP.

Sedimentologist or Sedimentary Petrolo-gist/University of California, Santa Barbara. Applications are invited for a tenure track appointment in soft rock geology to be filled in 1981– 92. Rank dependent on qualifications and exper-ence but preference will be given to the assistant professor level. Applicant should normally have a Ph D. and strong field-orientation and quantitative background. The candidate will be expected to devalop & strong research program in clastic sedi-mentation as related to beein analyses. The candi-date will also be expected to teach at both under-graduate and graduate levels and interact with students and faculty of the department, particularly in the general areas of clastic degenesis, volcanic processes, paleomagnetics, as well as field geology.

Additional duties may include leaching physical geology and summer field geology.

Please send resume, other documentation of

abilities, and four letters of recommendation by August 31, 1981 to Dr. Arthur G. Sylvester, Chalman, Department of Geological Sciences, University of California, Santa Barbara, CA 93106. Telephone

The University of California is an affirmative ac-

Postdoctoral/Research Associate Positions, The Johns Hopkins University, Ap-piled Physics Laboratory, Positions are svali-able for studies of magnetospheric-ionospheric couping, hydromagnetic waves, and plasma inslabilities in the lonosphere and magnet The selected candidates will participate in the analyses and interpretation of data from spacecraft and ground-based radars as well as in the development and implementation of new ground-based and spacecraft studies. Positions are for one year and spacecrant sucres. Positions are for one year and are renewable. Tenure may begin at any lime through September 1, 1981. Applications should be addressed to Mr. Steven F. Sayre, Dept. ADI-15. The Johna Hopkins University, Applied Physics Laboratory. Johna Hopkins Road, Laurel, MD 20130.

An equal opportunity employer, m/l.

Physical Oceanographer. The Pacific OCS Office, Bureau of Land Management, is seeking qualified candidates for a stall oceanographer to supervise contracted marine environmental research. The primary areas of research will be physical oceanographs and melanologic fluids include. ical oceanography and meteorology. Duties include serving as a contracting officer's authorized tapes serving as a connecting officer, authorized representative, developing study plans and work statements and solveing management on matters within the candidate's area of expense. Grade level: 68 9/11/12, satary \$18,565-26,651-26,651-364-4 a current/SF 171 by Juhis 6, 1981 to Administrative Officer, Burstan of Lund Menagement. (840 W. Studi 61 Am. 200, Los Acquies, GA 900 T. FC more telepromotion cell 213-669-7120.

Mineralogy and Petrology. Applications are invited for a faculty position at Weeber State College, effective September 1981. This is a permanent faculty position with rank, aslary, and tenure track status determined by qualifications. Responsibilities include teaching undergraduate courses in bilities include teaching undergraduate courses in mineralogy, petrology, and geochemistry and some combination of mineral deposits, structural geology and introductory geology. Ph.D. preferred, WSC is a large (10,000 students) undergraduate college with a strong geology program graduating about 10–15 majors per year. The college is situated in northern Utah at the boundary between the Rocky Mountain and Great Basin Provinces and adjacent to the Overthrust Belt. The Department is well equipped for field-oriented teaching and research. equipped for field-oriented teaching and research.
The closing date for applications is July 1, 1981. ons, including evidence of teaching profidency and the names of three references should be sent to S. R. Ash, Chairman, Department of Geology/Geography, Weeber State College, 3750 Harrison Blvd., Ogden, Utah 84408. An equal opportunity/affirmative action employer,

Research Seismologist. The Alexandria Leboratories of Teledyne Geotech Invites applications from Ph.D.-level seismologists to work on problems related to the comprehensive and threshold test ban treaty negotiations. Applicants should have background in such topics as theoretical seismology, saismic data analysis, seismic data gathering, advanced scientific computing, and computer sys tems. To apply please send your resume to Jean
Hill, Pesonnel Department, Teledyne Geotech, 314
Montgomery Street, Alexandris, Virginia 22314.
An equal opportunity employer.

Visiting Lecturer in Geophysics. Geology Department seeks one year visiting lecturer 1981—82 to teach expioration geophysics and sested with operation of sarbiquake leboratory (Includes WWSSN Station). Require Ph.D. or nearly completed Ph.D. Apply to the Geology Department Linker. ed Ph.D. Apply to the Geology Dapartment, University of Montana, Missoula, MT 59812. Deadline August 1, 1981: Telephione (408) 243-2341. EEO/AA employer.

Arizona State University, Department of Chemistry. Visiting professor, 1982—83 soldernic year or part thereof. We speck a person or persons with established research programs in geochemie dy mineral gryphology, and/or solid sigle chemistry in leach advanced apacial, piping course(s); if strength is country to be advanced apacial, piping course(s); if strength is country of a country to be advanced and success, and birthe own reading the party of a country of a country



physical sciences Announce special meetings, workshops,

Advertise services, supplies, and instru-

short courses, and calls for papers.

A classified ad in EOS, the weekly news paper for the geophysicist, will get re-

Low advertising rates, easy-to-meet cop deadlines, and a broad readership make EOS the medium for the message.

> Place your ad today Call toll free: 800-424-2488

Research Position in Chemical Oceanos, phy. California institute of Technology. Division

UNOLS Executive Secretary

The University-National Oceanographic Laboratory System (UNOLS) is soliciting applications for an Executive Secretary, UNOLS is an organization of academic institutions for the coordination and planning of aceanographic facilities, chiefly research vessels. The Executive Secretary administers the functions of UNOLS and heads the UNOLS Office which is located at and hosted by a Member laboratory. New office location is now pending. Institutions which have signified an intention to propose hosting the office

University of Delaware

The Johns Hopkins University, Chesapeake Bay Institute Lamont-Doherty Geological Observatory of Columbia University University of Southern California. Institute for Marine and Coastal Studies

University of Washington Woods Hole Oceanographic Institution

it is anticipated that proposing institutions will negotiate with one or more applicants to become a part of their proposal, and selection will be based, in part, on the qualifications of the successful applicant who will become an emolovee of the host institution. Required qualifications include experience in oceanographic research and knowledge of research ship operations. Salary is negotiable depending on professional qualifications. Deadline for applications is July 31, 1981.

For further information, contact:

UNOLS Office Box 54P

Woods Hole Oceanographic Institution Woods Hole, MA 02543

(617) 548-1400, Ext. 2352 An equal opportunity employer M/F/H=



Physical Oceanographer: Memorial University of Newfoundland. Memorial University undland in St. John's seeks to fill two faculty positions in physical oceanography. One poretical oceanography. Interest and experience in carrying out field programs is desirable. Candidates for both positions should hold a Ph.D. in physical oceanography, or a closely related field (e.g. fiuld

The program in physical oceanography at Memorial University is new and offers the successful applicant an opportunity to participate in the development of this field in a frontier area. Memorial University is located in St. John's, Newtoundland, which is rapidly becoming a centre of ocean studies related to lisherles and offshore hydrocarbon devel-

opment in Eastern Canada. Salary will be commensurate with experience

cations, including curriculum vitae and the names of three referees, are to be submitted to: Dr. C. W. Cho

Department of Physics Memorial University of Newfoundland St. John's, Newfoundland

Faculty Position/University of Ataska, Fair-banks. Applications are invited for a tenure track faculty position in economic geology in the Geology Geophysics Program to teach undergraduate and graduate courses in ore deposite, mineralogy.

d exploration geology.

Applications should have demonstrated practical experience in mineral exploration, regional and detaled geologic mapping as well as a commitment to research in the geneals of ore deposits. The candidate will be expected to pursue a vigorous gradue's teaching and research program in economic geology with students primarily oriented toward ca-

reers in the mineral industry.

Preference will be given to individuals with expensional programme and

Preference will be given to individuals with experience in arctic or subarctic minerale research and a record of close collaboration with the mineral industry. Academic rank and salary commensurate with experience. Ph.D. required.

Send resume and three letters of reference Difector. Division of Geosciences, University of Alaska, Farbanks, Alaska 98701. Applications will be accepted until June 30, 1981, or until falled.

The University of Alaska is an equal poportunity.

The University of Alaska is an equal opportunity/

Sedimentologist-Sedimentary Petrogra-pher/Ohio State University. The department of Geology and Mineralogy Invites applications for a tenure track faculty position in sedimentology-sedimentary petrography. The appointment is avail-able from August 1981. Salary and rank compatitive and company to the

Applicants should send resumes and names of at least three referees or address inquiries for further Information to Peter-N. Webb, Dept. of Geology and Mineralogy, The Ohio State University, 125 South Oval Mall, Columbus, Ohio 43210. Closing

Salary and rank competitive and commensurate

The Ohio State University is an equal opportuni-

Selemology. Research associate position antic ipated (September 1, 1981), telemetry monitoring project in Virginia. Problems focus on seismicity and neotectonics in the state. Prefer M S geophys icial with thesis in observational seismology, but others considered. Applications, transcripts and two letters of recommendation to: Dr. G. A. Bollinger, Selemological Observatory, VPL&SU, Blacksburg, Virginia 24081. Deadline for receipt of applications

is August 1, 1981. VPI&SU is an equal opportunity/affirmative action

Research Fellow/Sedimentary Geochemia-try. The Australian National University invites ap-plications for appointment as research fellow in sedimentary geochemistry, Research School of Earth Sciences. The School has a well equipped trace element laboratory, including an MS7 Spark Source Mass Spectrometer, with access to electron microprobe and XRD (aclittles-

The successful applicant should hold a Ph.D. degree and have a good background in geology, geo chemistry, analytical chemistry, sedimentology and chemistry, analytical chemistry, sedimentology and Pre Cambrian geology and ahould have experience in the use of the above analytical techniques. He or she will be expected to participate in joint research projects dealing with the use of trace els-ment geochemistry in elucidating the composition and evolution of the Earth's crust through studies of

sedimentary rock sequences.
In addition, applicants are invited to aubmit research proposats detailing the general research di-rections and specific projects which they would wish to pursue. Further information concerning the position can be obtained directly from Dr. S. R.

Applicants should submit a detailed curriculum vies of three referees.

three years in the first instance with the possibility of extension to five years. Selary rango: \$A19132 to \$A24972 per annum (\$A1 = \$US1,14). Superannuation, housing assistance, reasonable appoint-

The University reserves the right not to make an ilment or to make an appointment by invitalion at any time.

Applications should be sent to The Registrar. The Australian National University, PO Box 4, CANBERRA, ACT 2800, AUSTRALIA by 3 AU-

Biogeochemist or Organic Geochemist. Research assistant professor with interest in organic metter cycling in coastal sediment systems, as part of interdisciplinary group. Academic year appointment with opportunity for renewal Resume, names of three references, and letter of research interests by July 1 to L. Mayer, Ira C. Darling Cen elty of Maine at Orono, Walpole, Maine 04573. Equal opportunity/affirmative action employer.

Crustal Selemology: Princeton Univer-elty. Candidates with an interest in any of the fol-lowing are invited to apply for research staff sp-

- 1. Marino soismic data anetysis and struc-
- ture of oceans and ocean margins.

 2. Narrow and wide angle reflection seismol-
- ogy applied to continental crustal geology.

 3. Wave propagation theory and techniques of seismic data analysis. Princeton University has an ongoing program for

the creative reanalysis of existing multichannel relieution data—such as COCORP and USGS of shore data. Special projects are undertaken from time to time to collect field data in critical areas or to test new methods of data collection and analysis. A high performance 32 bit minicomputer system for data analysis and theoretical work is to be installed Applicants should send curriculum vites and a list

Robert A. Phinney

Department of Geological and Geophysical Sciences Princeton University Princeton, NJ 08544

Or inquire: 609-452-4118. Date of appointment and salary are negotiable. Princeton University is an equal opportunity em-

Consejo Nacional de Investigaciones Cientificas y Técnicas

CHIEF OCEANOGRAPHER

A postdoctoral scientist with several years experience in physical oceanography is required at IADO (Instituto Argentino de Oceanografia), a joint institution of the Consejo Nacional de Investigaciones Científicas Y Técnicas (National Research Council), the Universidad del Sur. Bahía Blanca, and the Armada Argentina (Argentine Navy).

The applicant, in addition to research and postgraduate teaching in his own field, will also be responsible for the planning, coordination, and supervision of activities in other branches of oceanography at large.

The position is under the auspices of a joint program of the Consejo Nacional de Investigaciones Científicas y Técnicas (CONI-CET) and the Interamerican Development Bank (IDB). It will be initially of medium duration, and is renewable.

It will be located at Bahia Blanca. Salary and fringe benefits according to qualification. Knowledge of Spanish language will be considered an advantage. For consultations or submitting applications, contact:

Señor Presidente del Consejo Nacional de Investigaciones Científicas y Técnicas Avda. Rivadavia 1917 (1033) Buenos Aires, Argentina.

Applications should include complete academic and professional background along with a list of publications as well as names and addresses of three references.

AGU

New Member Sponsors

One hundred sixty-six members were elected between March 31 and April 30, 1981. The AGU members who sponsored them are listed below. Earlier lists were published March 24 and April 28.

Three Members: Robert B. Smith. Two Members: M. S. T. Bukowinski, David S. Chapman, Robert A. Duncan, Bryan L. Isacks, Charles M. Keefer, LaVerne D. Kulm, James S. McClain, Forrest Mozer, W. J. Raitt, Thomas C. Royer, and Donald U. Wise.

One Member: Thomas J. Ahrens, Walter Alvarez, Don Anderson, James G. Anderson, Kinsey A. Anderson, Moha Ashour-Abdalla, Steven Bachman, George E. Backus, Fred Baker, Steven C. Bergman, Dale Bibee. Syeinbjorn Bjornsson, Ross A. Black, D. L. Blackstone, Jr. Gunnar Bodyarsson, Frances M. Boler, Martin, H. P. Bott, E. Boyle, L. W. Braile, Randolph W. Bromery, Charles A.

Brott, Robert C. Brown, R. L. Bruhn, Roger G. Burns. Roben S. Carmichael, Mingteh Chang, Charles R. Chap-pell, R. J. Clegg, John W. Clough, April M. Clowes, Charles E. Corbalo, Charles S. Cox, Richard G. Craig, Kenneth M. Creer, Geoffrey F. Davies, Paul M. Davis, Howard W. Day.

Paul S. DeCaril, Robert E. Dennis, Sleven R. Dickman, F. A. Donath, H. James Dorman, Leroy M. Dorman, Charles L. Drake, Richard E. DuBroff, Fred Duennebler.

Dieter H. Ehhalt, David S. Evans, Hans P. Evgster, Leonard S. Fedor, Michael Fehler, Robert W. Ferguson, Henry F. Filegel, L. Nell Frazer, F. A. Frey, A. Shelby Frisch, T. J. Fitzgerald, Joseph Frizado, Cliff Frohlich, Kazuya Fujita, Michael O. Garcia, Ronald J. Gibbs, Freeman Gilbert, R. W. Girdler, Billy Price Glass, Ambrose Golcoechea, Melvyn L. Goldstein, Paul Greisman.

Frank Hadsell, Gregory D. Harper, C. G. A. Harrison, Haistead Harrison, Early A. Haskin, Gary E. Hauser, Craig Haistead Harnson, Larry A. Haakin, Gary E. Hauser, Craig
O. Hayerga John G. Headock, Hugh C. Heard, Robert A.
O. Hayerga John G. Headock, Hugh C. Heard, Robert A.
Helliwell; Thomas E. Holzer, Jose Honnorez, Lonnie L. Hood,
lett, Thomas E. Holzer, Jose Honnorez, Lonnie L. Hood,
Robert Houtz, Robert L. Huguenin, Ru J. Hung, Anthony IrRobert Houtz, Robert L. Huguenin, Ru J. Hung, Anthony IrVing Elliving H. M. Iyer, Arisel G. Johnson, T. H. Jordan,
John Joseph Karlet M. Allen Kava Charles D. Kasilon

JoAnn Joselyn, Dölfglas L. Karle: M. Allan Kays, Charles D. Keeling, Dölfglas L. Karle: M. Allan Kays, Charles D. Keeling, George M. Kella: W. Kertz: Raz: Khaleel, Carl Kisslinger, George M. Kella: Jan Kouba, Led Kristlansson, Arhur F. Peler: K. Kitarlicie, Jan Kouba, Led Kristlansson, Arhur F. Kuckes, Andre S. Kusubov, Helmut E. Landsberg, Blorn T. Kuckes, Andre S. Kusubov, Helmut E. Landsberg, Blorn T. Larsen, Edwin E. Larson, B. E. Leake, Darrell I, Leap, Con-

way B. Leovy, Joel S. Levine, J. G. Liou, Austin Long, Danlei P. Loucks, Allen Lowrie, William J. Ludwig, Alan M. Lumb, Timothy M. Lutz.

William D. MacDonald, R. M. MacQueen, Thomas Mad-

dock, James Magill, David C. Major, Stephen D. Majone, Muril H. Manghnani, Robert Mark, Bruce D. Marsh, David L. Martin, Russell McDull, Michael B. McElroy, L. D. McGinnis, Stuart McHugh, Randolph Moberly, Walter Mooney, C. B. Moore, Dennis Wilson Moore, H. J. Morel-Seytoux, Helmut Morliz, L. J. Patrick Muffler, Patricia E. Murtha, Frederick Nagle, Manuel Nathenson, Richard S. Naylor, David L. Neberi, Anthony Nekut, F. M. Neubauer, Shlomo P. Neuman, R. W. Nicholis, Henry Joseph Neibauer, Richard W. Nightingale, Hallan C. Noitimier, Amos Nur.

W. P. Olson, Richard E. Orville, Benjamin M. Page, Donaid F. Palmer, Chung Park, Robert L. Parker, David F. Paskausky, Bryan Pearce, Henry Perkins, K. A. Pilizer, John A. Philipotts, Morris B. Pongratz, Raymond A. Price, Ivar B. Ramberg, Joseph B. Reagan, Charles R. Real, David L. Reasoner, Irwin Remson, Eugene D. Richard, John D. Richardson, Randall M. Richardson, Robert E. Riecker, Peter A. Rigotti, Peter Rogers, William M. Roggettinen, Wil-

liam B. Rossow, Peter H. Roth, Jacob Rubin, David Rusch, Sidney L. Russak.

Rafael Sanchez, Kim David Saunders, Samuel M. Savin, David W. Saxlon, Marc L. Sbar, Kenneth F. Scheldegger, John William Schlue, Ulrich Schmidt, Robert W. Schunk, David Seidemann, Stephen Self, Margaret Ann Shea, Gordon G. Shepherd, Peter N. Shive, Loren Shure, John M. Sinton, George L. Siscoe, Charles W. Slaughter, David B. Slemmons, Don F. Smart, Douglas L. Smith, Eugene I. Smith, Scott B. Smithson, Charles P. Sonett, Frank Spera, R. R. Steeves, Daniel B. Stephens, J. Carl Stepp, Robert G. Stone, William D. Stuart, Desiree E. Stuart-Alexander,

Peter Styles, Steven T. Suess, Kendall L. Svendsen. Pradeep Talwani, Michael A. Temerin, Ta-liang Teng, H. R. Thierstein, Ronald J. Thomas, T. R. Toppozada, Donald L. Turcotte, Petr Vanicek, Kenneth L. Verosub, Thomas A. Vogel, Elstratios G. Vomvoris, Carl A. Von Hake, William B. Wadsworth, Harve S. Waff, Mary Emma Wagner, Clyde Wahrhaltia, Raymond J. Walker, C. Wang, Steve Wegener, Ray F. Weiss, J. E. White, John M. Wilcox, James G. Willlams. John Wilson, W. P. Winn, I. J. Won, David D. Wooldridge, Francis T. Wu, Shi Tsan Wu, Klaus Wyrtki, Gour-Tsyh Yeh, Hsueh-Wen C. Yeh.

Meetings

Applied Glaciology Symposium

The International Glaciology Society has slated its second meeting on the applied aspects of snow and ice research for August 23-27, 1982, at the Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire. This Second Symposium on Applied Glaciology will include technical sessions on the engineering problems of floating ice; engineering problems of ground ice; icebergs and glaciers; properties and behavior of snow and ice; snow removal and control; avalanche control and snow pressure; ice accretion; and modeling techniques in applied

For additional information, contact the Secretary General, international Glaciological Society, Lensfield Road, Cambridge CB2 1ER, United Kingdom. 🔊

Coastal Engineering Conference

The 18th International Conference on Coastal Engineering, will be held November 14-19, 1982, in Cape Town, Republic of South Africa.

Topics to be covered at the conference include wind current and wave action; tides and long waves; sedimentary processes and coastal morphology; estuary and inlet behavior, coastal structures and recreational facilities; ship motions and harbor entrence design; ocean outfall design and construction; and environmental aspects of coastal en-

Five copies of a synopsis (not to exceed two pages) of papers proposed for the conference should be sent to Billy L. Edge, Secretary, Coastal Engineering Research Council, Department of Civil Engineering, Clemson University, Clemson, SC 29631. Deadline is October 31, 1981. 6

Underwater Mining Institute

The 12th Underwater Mining Institute is scheduled for October 20-22 in Madison, Wisconsin. The program will include presentations on mineralogy of marine sulfide deposits; tectonic setting for spreading center sulfide deposits; seafloor sulfides in the Galapagos and other Pacific areas; new developments in southeast Asia offshore tin operations; geophysical techniques for finding underwater copper lodes; new geochemical techniques for marine minerals exptoration; changes in the international mining trade of relavance to marine mining; and the impact of sea grant minerals research on industry. The program will also include tours to local research laboratories.

For registration information, contact Gregory Hedden, Sea Grant Advisory Services, University of Wisconson, 1815 University Avenue, Madison, WI 53706 (telephone:

For technical program information, contact J. Robert Moore, Marine Science Institute, University of Texas, P.O. Box 7999, University Station, Austin, TX 78712 (telephone: 512/471-4816).

AGU Midwest Meeting

September 17–18 Minneapolis, Minnesota

Abstract Deadine: July 1 Convenor: V. Rama Murthy

Papers and posters originating in or pertaining to the region are solicited for the following special ses-

Muntle structure and dynamics. Contact Geoffrey Davies or Clem Chase.

Rock water interactions: Hydrothermal processes and metallogenesis. Contact William Seylried. Precambrian crustal evolution of the North American continent. Contact Paul Welblen.

Geomagnetism and paleomagnetism. Contact Su-Hydrology in the mid-continental U.S. Contact H. O. Plannkuch or E. C. Alexander, Jr.

Use standard AGU format (see page 20 of January 13 Eos) and send original and two copies of abstracts to AGU Midweat Meeting, 2000 Florida Avenue, N.W., Washington, D.C. 20009. Abstracts will be published in Eos, with a substantive meeting report after the meeting. There will be no abstract charge.

Aquifer Protection Policies

A special program entitled 'Effects of New Aquifer Protection Regulations and Policies on Ground Water Management' will be held at the American Society of Civil Engineers' Spring Convention and Exhibit during the week of April 19, 1982, in Las Vegas, Nevada. The program is sponsored by the Hydraulic Division's Committee on Ground Water Hydrology and by the Environmental Englneering Division's Committee on Hazardous Waste Man-

A call for papers has been issued for the following topics: review of regulatory activity, future protection regulations, and policies; groundwater quality monitoring; design of well networks; groundwater studies stemming from regulations, including remedial measures; and ongoing and needed research. Research topics should address pollution sources, transport and fate of pollutants, methods of detection, and aquifer rehabilitation.

Geophysicists interested in presenting a paper should send a one-page abstract to Richard J. Schicht, Illinois State Water Survey, 605 East Springfield Avenue, P.O. Box 5050, Station A, Champaign, IL 61820 (telephone: 217/333-2594). Deadline is July 31. 39

Workshop on Remote Measurement of **Underwater Parameters**

This workshop was held at Bolkesjo, Norway, October 30 to November 1, 1980. It was arranged by the Royal Norweglan Council for Scientific and Industrial Research, Space Activity Division; Institute of Geophysical Research, Universily of Bergen; and Office of Naval Research, Arlington, Virginia. It was sponsored by the Royal Norwegian Council for Scientific and industrial Research, the North Atlantic Treaty Organization, and the Office of Naval Research.

One may conclude from the meeting that the idea that it may be possible to determine any subsurface variables of the ocean by remote sensing is attractive in principle, but realizable now, in a severely limited manner, and still possible of advancement. Sound waves are now used for tracking SOFAR floats to map out deep and mid-level currents, and acoustic tomography offers possibilities that are now being explored in the field, with the first tentalive results now being reported. Acoustic tomography measures a combination of velocity and sound speed fields over the water column, and the data can be interpreted to give mean variables and a number of integral measures of water properties as well as statistical measures of the field of variables. The upper mixed layer is not so well sampled by acoustic tomography, so for the upper layer, one will have to rely upon other methods. In saltwater, electromagnetic waves cannot be used profitably; for brackish or fresh water overlying sait water, radar monopulse methods offer some promise. Such methods are in routine use for ice proskes and rivers, and extension to estuaries may prove useful and practical.

Satellite interrogation of drifters, and shore station tracking of driftling buoys are other methods of obtaining information about the ocean without having to go there each lime one wants information.

Among the active methods of sensing variables in the upper ocean are ground wave and ionospheric scatter radar. The ground wave radar method, one example of which is CODAR, when used from shore, can sense the current field in the upper 1/2 meter of the ocean with a spacial resolution of 1.5 km² and 0.10 m/s. While a few examples were given of synthetic aperture radar (SAR) signatures in SEASAT-SAR data, the processing algorithm was not described in sufficient detail to enable one to make any judgement about the method, although in principle it should be possible to infer current along one direction from Dopplershifted reflections. The SAR data also show a strong correlation between bathymetry and sea surface roughness. As at previous workshops where these data have been presented, there was little, if any, analysis given of the dynamics of the processes. The active optical methods, using laser light sources, take advantage of the following effects: the Rayleigh scattering broadens the spectral width, and the broadening is temperature dependent. Thus, one may be able to measure temperature by observing the reflected light from pulsed, range-gated lasers.

Next comes Raman backscatter for measurements of 84 linity, temperature, and other variables, and then comes Brillouin scattering to sense sound velocity. When a very Intense laser signal hits the water, it will also heat it and generate an acoustic signal. The reflection of the acoustic signal back to the surface (by density structures) will in lum generate a measurable surface signature. One can use the for depth sounding from airplanes and, ultimately, from even more remote platforms. The combination of possibility ties, although few of them are now at a stage ready for routine practical use, suggests that one should follow developments closely. The methods, so far, seem to be mainly useful in the upper 50 m of the ocean but may some day be extended to several times that depth. This will tell us very little about the deeper water column. But the possibility of obtaining synoptic data, even in the upper few meters, seems interesting. The technology needs to be worked out and the oceanographic community need not yet hold its collective breath and sit around and wait, but the new methods may be upon us In a few years. The active and passive remote sensing of water properties has, of course, also been extended to sensing of biological properties. Here the workshop contained a very interesting set of papers on algorithms and the inverse problem and an example of application of color measurement to mud flat and tid-

The first paper was by N. K. Hojerslev, who showed that different regions of the ocean have sufficiently different plankton-related color that a universal algorithm for interpreting color in terms of biological measures will have serious shortcomings. The next paper, by J. Fischer and H. Grassi, who had examined the problem of remote sensing of particulates, found that the problem of determining particulate matter variables from color observations was not well conditioned and that the matrix really had only two linearly independent characteristic vectors. The tentative conclusion of this listener to these two papers was that below one can use color to determine biological variables, one needs to introduce some information about local biological properties as a constraint on the inversion process. This means that one needs biologists to help with the interpretation; one cannot find a way where the technology system and the computer can do it all by themselves. This should not be a source of wonder because biology is a nontrivial branch of science and cannot be left to automation. One has to develop a certain judgement and expertise before one can produce useful results.

The Coastal Zone Color Scanner provides useful information for biologists, but the information from the intensity of color bands cannot be used blindly, it has to be interpreted through the use of knowledge about local biology as a constraint on the inversion process. An example of how to incorporate local knowledge in an inversion problem was given by Prober, Bahr, and Dennert-Muller, who interpreted the LANDSAT images from different channels, in terms of tidal flat classes, including dry sand, wet mud, and others by using 'training fields' and in situ establishment of field characteristics. The use of these training fields introduced the local constraint on the inversion process and made it possible to classify a large region from LANDSAT data at ter field work in a limited area that covered the important

This is apparently the direction in which one has to seek methods for interpreting upper ocean color. Also, no doubt, the same method can be used with active sensors, where one senses the color quality of reflection of laser lights from different depths, including fluorescence effects.

While some of the methods seemed kind of far from practical realization in the near future, there is rapid technology development under way.

The workshop was informative for the participants, and the sober assessments provided by the working groups showed that one cannot dismiss remote sensing techniques out of hand, that the technologists need to encounter scientists to learn what one should look for, and it showed how one may adjoin specialist knowledge to remote sensing data. In that sense the workshop was educational, realistic, and productive of sober evaluations of methods. An abstract volume will be available shortly from the Royal Norwegian Council for Scientific and Industrial Research, Space Activity Division, P.O. Box 309, Blindern, Gaustadalien 30 D, Oslo, 3, Norway.

This meeting report was prepared and submitted by Erik Mollo-Christensen of the Department of Meteorology and Physical Oceanography at MIT, Cambridge. 🕸

> For Your Convenience and More Rapid Service

Call Toll Free 800-424-2488

You Can Now

Place book orders

 Change your mailing address • Inquire about AGU services

VISA & Master Card charges are welcome. Orders over \$50.00 may be billed (postage & handling costs will be added).

If you are charging your purchase, please have your charge card ready when you call,

Calls answered 9 a.m. 4:30 p.m. E.S.T. from anywhere in the continental U.S.A.

Geophysical Year

(Boldface indicates meetings aponsored or ponsored by AGU.)

May 27-29 Canadian Meteorological and Oceanographic Society 15th Annual Conkatoon, Saskatchewan, Canada, gress, Saskatoon, Saskatonewan, Canad (B. E. Goodlson, Program Chairman, Atmospheric Environment Service, 4905 Duflerin Street, Downsview, Ontario M3H 5T4

June 1-4 First JECSS Workshop Tokyo. Japan. Sponsor, Tsukuba University. (Takashi ichiye, Dept. of Oceanography, Texas A&M University, College Station, TX

June 1-5 Second International Symposlum on inertial Technology for Surveying and Geodesy, Banff, Canada. Sponsors, AGU, Canadian Institute of Surveying, Univ. of Calgary. (Klaus-Peter Schwarz, ISS Symposium 1981, Division of Surveying Engineering, Univ. of Calgay, Calgary, Alberta T2N 1N4 Canada.) June 3-4 Symposium on the Ecology and Management of Reservoirs, Université Le-val, Quebec, Canada. Sponsors, Unesco, Université du Quebec, Université Laval, Hydro-Quebec, Societé d'Energie de la Bale James. (P. G. C. Campbell, Université Quebec, INRS-Eau, C.P. 7500, Ste. Foy, Quebec G1V 4C7 Canada.) June 4-5 Eastern Snow Conference, Syra-

cuse. N.Y. (B. E. Goodlson, Program Chalman, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontarlo M3H 5T4 Canada.)

June 7-11 Eighth Ocean Energy Conference for the Department of Energy, Washington, D.C. Sponsor, Marine Technology Society. (Harry Irwin, Marine Technology Society, 1730 M St., N.W., hington, DC 20036.)

June 8-10 International Geoscience and Remote Sensing Symposium, Washington D.C. Sponsors, AGU, IEEE Geoscience and Remote Sensing Society. (F. T. Ulaby, Remote Sensing Laboratory, Univ. of Kansas Center for Research, Inc., West Campus, Lawrence, KS 66045.)

June 14-19 Second International Conference on Urban Storm Drainage, Urbana, III. Sponsors, Univ. of Illinois, Internation Liaison in Urban Storm Drainage, International Association of Hydraulic Research, International Association of Water Pollution Research, American Society of Civil Engineers. (B. C. Yen, Department of Civil Ensering, Univ. of Illinois, Urbana, IL

June 15-19 International IEEE/APS Symposlum, National Radio Science Meeting, and international IEEE/MTT Symposium. Los Angeles, Calif. (Prof. N. G. Alexopoulos, 7732 Boelter Hall, Department of Electrical Sciences, Univ. of California, Los Angeles, CA 90024.)

lune 22-26 International Symposium on Erosion and Sediment Transport Measurement, Florence, Italy. Sponsors, IAHS, Inemational Commission on Continent erosion, National Research Council of Itay. (P. Tacconi, Secretary of the Organiz-ing Committee, istituo di Ingegneria Civile Via S. Maria, 3 50139 Firenze, Italy.) June 23-26 Seventh International Symposlum on the Machine Processing of Remolely-Sensed Data, West Lafayette, Ind. Sponsor, Laboratory for Applications of Remote Sensing, Purdue Univ. (D. B. Morrison, Purdue Univ./LARS, 1220 Potter Dr., West Lefayette, IN 47906.)

June 24-26 International Symposium on Real-Time Operation of Hydrosystems, /aterioo, Ontario, Canada. Sponsor, Wa-Resources Group, Univ. of Waterloo. (T. E. Unny or E. A. McBean, Univ. of Waterico, Department of Civil Engineering, Waterloo, Ontario N2L 3G1 C June 29-July 2 22nd United States Sympo-

slum on Rock Mechanics, Cambridge,
Mass. Sponsor, Massachusetts Institute of
Technology. (Barbara Dullea, Coordinator,
Center for Advanced Engineering Study
Seminara MIT Combridge MA 02139.) Jeminara, MIT, Cambridge, MA 02139.) lune 29-July 3 Conference/Workshop on Hetsrogeneous Catalysis—Its Importance to Almospheric Chemistry, Albany, N.Y. Sponsors, NSF, NASA. (V. A. Mohnen, At-mospheric Salescence. Ospheric Sciences Research Center, State Univ. of New York, Albany, NY

June 29-July 11 Seminar on Fluid-Dynamical Problems in Astrophysics and Geophysics, Chloago, Ill. Sponsors, American Mathematical Society, Society for Industrial and Applied Mathematics. (Meeting Arrangements Department, American Mathematical Society, Post Office Box 6248, Providence, R.I.)

luly 6-11 Geocongress 81-South African Geodynamics Project and 3rd international Platinum Symposium, Pretoria, South Africa. Sponsors, Geological Society of South Africa, South African National Committee for the International Union of Geological Sciences. Sciences, Society of Economic Geologists.
(The Symposium Secretarial S. 217, CSIR,
P.O. Box 395, Pretone 0001 Republic of South Airloa.)

July 8-10 National Conference on Environmental Engineering, Atlanta, Ga. Sponsor, Environmental Engineering Division of American Society of Civil Engineers. (F. Michael Saunders, 1981 National Conference on Environmental Engineering, School of Civil Engineers, Georgia Institute

of Technology, Atlanta, GA 30332.)

July 15-17 Summer Computer Simulation Conference, Washington, D.C. Sponsors, natrument Society of America, the Society for Computer Simulation. (William E. Buchanan, Applied Physics Laboratory, Johns Hopkins Road, Laurel, MD 20810.)

July 21—23 Chapman Conference on Spatial Variability in Hydrologic Modeling, Fort Collins, Colo. (Meetings AGU, 2000 Florida Ave., N.W., Washington, DC 20009.) July 21-30 21st General Assembly of IA-

SPEI, London, Ontario, Canada, (A. E. Beck, Department of Geophysics, Univ. of Western Ontario, London, Ontario N6A 5B7 Canada.\

July 27-30 Eighth International Symposlum on Urban Hydrology, Hydraulics, and Sediment Control, exington, Ky. (Don J. Wood, Departme of Civil Engineering, 206B Anderson Hal Univ. of Kentucky, Lexington, KY 40508.) Aug. 3–15 IAGA Fourth Scientific Assembly, Edinburgh, United Kingdom. (B. R. Leaton, institute of Geological Sciences.

Edinburgh EH9 3LA United Kingdom.) Aug. 4-7 International Conference on Energy Education, Providence, R.I. (Donald Kirwan, Conference Chairman, Office of Energy Education, Univ. of Rhode Island,

Aug. 9-15 Symposium on Variations in the Global Water Budget, Oxford, United King-dom. Sponsors, ICCL, IAHS, INQUA. (Prof. R. E. Newell, Department of Meteo-rology, 54-1520, MIT, Cambridge, MA

Aug. 9-18 International Congress of Surveyors, F.I.G., Montreux, Switzerland. Sponsor, Fédération Internationale Des Geometres. (American Congress on Surveying and Mapping, 210 Little Falls Street, Falls Church, VA 22046.)

Aug. 10-14 International Conference on Basement Tectonics, Oslo, Norway. Spon sor, Norwegian Petroleum Society. (Roy H. Gabrielsen, Department of Geology, Univ of Oslo, P.O. Box 1047, Blindern, Oslo 3 Norway; or Don L. Baars, Department of Geology, Fort Lewis College, Durango, CO

Aug. 10-14 Water Forum 81: Technical State of the Art Exchange, San Francisco. Callf. Sponsors, American Society of Civil Engineers, Irrigation and Drainage Division, Committee on Drainage. (P. M. Mey ers, 509 North Roosevelt Bivd., Apt. D-105, Falls Church, VA 22044.) Aug. 10-19 20th General Assembly of the

International Union of Radio Science. Washington, D.C. (R. Y. Dow, National Academy of Sciences, 2101 Constitution Ave., Washington, DC 20418.) Aug. 17-28 Third Scientific Assembly of IA-

MAP with Extraordinary General Assembly, Hamburg, Federal Republic of Germany. (S. Ruttenburg, NCAR, P.O. Box 3000, Boulder, CO 80307.)

Aug. 17–18 Open Symposium on Mathematical Models of Radio Propagation, Washington, D.C. Sponsor, URSI. (J. R. Walt, Bidg. 20, Electrical Engineering De parlment, Univ. of Arizona, Tucson, AZ 85721.)

Aug. 17-22 Ninth International Symposium on Earth Tides, New York, N.Y. Sponsors, IAG, IUGG, Columbia Univ. (J. T. Kuo, 828 S.W. Mudd, Columbia Univ., New York,

Aug. 18-21 Second Siennial Conference and Exhibition of the Australian Society of Exploration Geophysicists, Adelaide, South Exproration Geophysicists, Adelaice, South Australia. (J. Haigh, Conference Chairman, P.O. Box 42, Unley, South Australia 5061.) Aug. 20–21 Second International Sympo-

sium on Computer-Aided Selsmic Analysis and Discrimination, North Dartmouth, Mass. Sponsors, Electrical Engineering Department, Southeastern Massachusetts University, IEEE Computer Society, IEEE Acoustics, Speech and Signal Processing Society. (C. H. Chen, Electrical Engineering Department, Southeastern Massachuseits University, North Dartmouth, MA

Aug. 24-26 International Symposium on Management of Geodetic Data, Copenhagen, Denmark, Sponsors, IAG, the Danish National Committee of IUGG, Geodaetisk Institut. (C. C. Techerning, International Symposium Management of Geodetic Data, Geodaetisk Institut, Gamlehave Alle 22, Charlottenlund DK-2920 Denmark.) Aug. 24-29 Eighth Annual Meeting of the

European Geophysical Society, Uppsala, Sweden. (C.-E. Lund, Chairman Local Organizing Committee, institute of Solid Earth Physics, Uppsala University, 8ox 556, 22 Uppsala, Sweden.)

Aug. 25-27. The Royal Institution of Charles of Surveyor Contents Collaboration

tered Surveyors Centenary Celebration, London, England, (Representative Rad-linski, American Congress on Surveying and Mapping, 210 Little Falls Street, Falls Objects VA 20048 Church, VA 22048.)

Aug. 28-Sept. 9 Aro Volcanism Sympo-alum, Tokyo, Japan. Sponsors, Volcano-logical Society of Japan, IAVCEI. (Daisuke

Shimozuru, IAVECEI Symposium on Arc Volcanism, Earthquake Research Institute. Univ. of Tokyo, Bunkyo ku, Tokyo 113 Ja-

Aug. 31-Sept 2 Third International Coltoquium on Mars, Pasadena, Calif. Sponsors, NASA, Lunar and Planetary Institute Division of Planetary Sciences of the AAS. (Conway W. Snyder, Jet Propulsion Laboratory, Pasadena, CA 91109.)

Aug. 31-Sept. 5 Symposium on Geodetic Networks and Computations, Munich, West Germany. Sponsor, IAG. (Deutsche Akademie der Wissenschaften, Marstellplatz 8, D-8000 Munchen 22.)

Sept. United Nations Symposium on Water Management in Industrialized Areas, Lisbon, Portugal. (Chairman of the Executive Committee, International Symposium on Water Management in Industrial Areas, Portuguese Water Resources Association, c/o LNEC, Av. do Brasil, 101, 1799 Lisbon,

Sept. 7-12 Third International Symposium on Antarctic Glaciology, Columbus, Ohto. Sponsore, International Commission on Snow and ice, international Glaciologica Society. (Institute of Polar Studies, Onto State Univ., 125 S. Oval Mail, Columbus, OH 43210.)

Sept. 8-12 American Society of Photogrammetry-American Congress on Surveying and Mapping Fall Convention, San Francisco, Calif. (L. W. Aggers, USGS. 345 Middlefield Road, Mail Stop 31, Monio Park, CA 94025.)

Sept. 13-17 National Water Well Association 33rd Annual Convention and Groundwater Technology Education Session. Kansas City, Mo. (NWWA, 500 Wost Wilson Bridge Rd., Worthington, OH 43085.)

Sept. 16-18 Oceans '81, Boston, Mass. Sponsors, Marine Technology Society. IEEE Council of Oceanic Engineering, AGU. (R. Nagle, Publicity Manager, Raytheon Company, 141 Spring St., Lexington, MA 02173.) Sept. 17-18 Midwest Meeting, Minne-

apolis, Minn. (Meetings, AGU, 2000 Flori-da Ave., N.W., Washington, DC 20009.) Sept. 17–18 Pacific Northwest Regional Meeting, Ellensburg, Wash. (Bob Bentley, PNAGU, Central Washington University, P.O. Box 1000, Department of Geology, Ellensburg, WA 98920.) Sept. 20-22 National Water Well Associa-

tion 34th Annual Convention and Exposition, Atlanta, Ga. (NWWA, 500 West Wilson Bridge Rd., Worthington, OH 43085. Sept. 28-Oct. 10 NATO Advanced Study Institute on Chemistry of the Unpolluted and Polluted Troposphere, Corfu, Greece (W. Jaeschke, Center of Environmental Protection, University of Frankfurt, Robert

Mayer-Str. 11, 6000 Frankfurt/Main, FRG.) Oct. 6-8 International Conference on Time Series Methods in Hydrosciences, Burlingsearch institute of the Canada Centre for inland Waters and Water-Resources Branch of Ontario's Ministry of Environment. (A. El-Shaarawi, Aquatic Physics and Systems Division, NWRI, Canada Centre for Inland Waters, P.O. Box 5050, Burlington, Onlario L7R 4A6 Canada.)

Oct. 11-14 Coastal Society's Seventh Annual Conference, Galveston, Tex. (N. West, Coastal Society Conference, Department of Geography and Marine Affairs, Univ. of Rhode Island, Kingston, Ri

Oct. 11-15 51st Annual International Meeting of the Society of Exploration Geophysicists, Los Angeles, Calif. (William L. Baker. Technical Program Chairman, c/o Chevron Oli Field Research Co., Box 446, La Habra, CA 90631.)

Oct. 13-15 Fifth Geopressured-Geothermal Energy Conference, Balon Rouge, La. Sponsors, Louisiana Geological Survey.

Department of Natural Resources; Energy Programs Office, Louislana State Universily; U.S. Department of Energy. (Ann Bachman. Conference Coordinator, Energy Programs Office, 105 Hill Memorial, Louislana State Univ., Baton Rouge, LA 70803.) Oct. 13-16 Division of Planetary Sciences

of the American Astronomical Society Annual Meeting, Piltsburgh, Pa. (B. Hapke, Dept. of Geology and Planetary Science, 321 Old Engineering Hall, University of Pittsburgh, Pittsburgh, PA 15260.) Oct. 14-16 Third Surveying and Mapping

Colloquium for the Petroleum Industry, Banff, Alberta, Canada, Sponsor, Canadian Petroleum Association. (Liz Hampton, Canadian Petroleum Association, 1500, 633 Sixih Ave., S.W., Calgary, Alberta,

Oct. 22-24 Fourth Conference on the Physics of the Jovian and Saturnian Mag-netospheres, Laurel, Md. Sponsor, NASA. (S. M. Krimigis, Applied Physics Laboralory, Johns Hopkins Univ., Laurel, MD

Oct. 26-30 Symposium on Quaternary Land-Sea Migration Bridges and Human Occupation of Submerged Coastines, La Jolla, Calif. Sponsors, Quaternary Shorelines Commission of the International Union for Quaternary Research, Scientific Committee of the World Confederation of Underwater Activities. (Patricla M. Masters, Scripps Institution of Oceanography, A-012, La Jolla, CA 92093.1

November 1-5 Sixth Biennial International Estuarine Research Conference, Gleneden Beach, Oreg. Sponsor, Estuarine Research Federation. (Jay F. Watson, Troasurer, USFWS Suite 1962, 500 N.E. Multnomah Street, Portland, OR 92232.)

Nov. 2-8 International Conference on the Venus Experiment, San Francisco Bay Area, Calif. Sponsor, NASA. (Dr. Lawrence Colin, Ames Research Center, Moffett Field, CA 94035.)

Nov. 9-11 Special Conference on the Mechanical Behavior of Salt, University Park, Pa. Sponsor, Rock Mechanics Laboratory. Department of Mineral Engineering, Penn sylvania State University (H. Reginald Hardy, Jr., Rock Mechanics Laboratory. Room 117, Mineral Sciences Building. Pennsylvania State University, University Park. PA 16802.)

Nov. 9-20 Second Symposium on Geodesy in Africa, Nairobi, Kenya. Sponsors. IAG, IUGG Local Committee of Kenya. IUGG Committee on Advice to Doveloping Countries, African Association of Cartography. (R. Omandi, Survey of Kenya, P.O. Box 30046, Nairobi, Kenya.)

Nov. 30-Dec. 11 43rd Session of the International Statistical Institute, Buenos Aires, Argentina, (Jim R. Wallis, IBM, Research Division, Box 218, Yorktown Heights, NY 10598; or G. S. Watson, Bernoulli Society for Mathematical Statistics and Probability, Department of Statistics, Princeton Univ., Princeton, NJ 08544.)

Dec. 3-5 Topical Conference on the Processes of Planetary Rifting, San Francisco Calif. Sponsor, Lunar and Planetary Instilute. (Rift Meeting, Projects Office, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058.)

Dec. 7-11 AQU Fall Meeting, San Francisco, Calif. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.) Dec. 18-19 Annual International Meeting of the Working Group on Mediterranean Ophiciltes, Florence, Italy. (Luigi Beccaluva, Istituto di Petrografia, Via Gramsci 9,

Geodynamics Series Volume 1

dynamics of the more stable regions of the earth.



Dynamics of **Plate Interiors**

43100 Parma, Italy.)

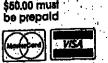
Editors, A. W. Bally, P. L. Bender, T.R. McGetchin, & R.J. Walcoli

An interdisciplinary investigation tocused on 4 major

areas of study: Instrumental Measurement of the Deformation of History and Mechanism of Plateaux Uplift

Veriloal Movements from the Stratigraphic Record Quaternory Vertical Movements This find report of the international Geodynamics Project. Working Group, 7 on Geodynamics of Plate Interiors, brings together a variety of papers dealing with the nature and origin of the

> Copublished by the Geological Society of America 164 pages / \$15.00 Hardbound / 20% member discount



American Geophysical Union 2000 Florida Avenue, N.W. Washington, D.C. 20009 Cail 800-424-2488 Toll free

"An extraordinary publishing event." *

Quantitative Seismology Theory and Methods

Volumes I and II

Kciiti Aki Massachusetts Institute of Technology Paul G. Richards Columbia University

"This truly exquisite text/monograph provides advanced students and professionals with a wonderfully detailed and comprehensive but lucid account of physical, mathematical and instrumentational principles which lie at the quantitative heart of modern seismology. . . . Hard to imagine any respect in which the book could be improved upon, whether in the writing or the production."

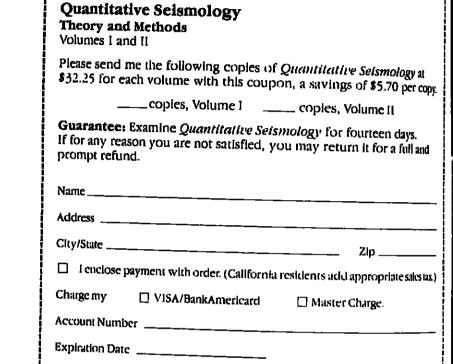
-Sci Tech Book News*

Volume 1 CONTENTS Preface/Introduction Basic Theorems in Dynamic Blasticity Representation of Seismic Sources Elastic Waves from a Point Dislocation Source Plane Waves in Homogeneous Media and Their Reflection and Transmission at a Plane Boundary Reflection and Refraction of Spherical Waves. Limb's Problem Surface Waves in a Vertically Heterogeneous Free Oscillations of the Earth Body Waves in Media with Depth dependent Properties Principles of Scismonietry

Volume 11 CONTENTS Preface/Introduction Analysis of Seismological Data Inverse Problems in Seismology Inhomogeneous Media The Scientic Source, Kinematics The Seismic Source: Dynamics Bibliography/Index

hardbound: 1059 \$37.95

Seismic Waves in Three-dimensionally 1980, 389 pages, 116 illustrations



SOAN REACIVE SERVICE OF A

Special 15% discount for readers of EOS

W. H. Freeman and Company

660 Market Street, San Francisco, CA 94104

Classified

Appendix 1: Glossary of Waves

hardhound 1058 \$37.95

Hildiography/Index

Appendix 2 Definition of Magnitudes

1980, 573 pages, 109 illustrations

EOS offers classified space for Positions Available, Positions Wanted, and Services, Supplies, Courses, and Announcements, There are no discounts or commissions on classified ads. Any type that is not publisher's choice is charged for at display rates. EOS is published weekly on Tuesday. Ads must be received in whing on Archday 1 week prior to the date of the

Replies to ads with box numbers should be addressed to Box ____ American Geophysical Union, 2000 Florida Avenue, N.V. Washington,

POSITIONS WANTED 1-5 times-\$1 00, 6-11 times-\$0.75. 12-26 times - \$0.55

POSITIONS AVAILABLE 1-5 times-\$2.00, 6-11 times--\$1.60, 12-26 limes - \$1 40

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS 1-5 times - \$2 50, 6-11 times - \$1.95.

STUDENT OPPORTUNITIES For special rates, query Robin Little.

POSITIONS AVAILABLE

Research Seismologist Boild Earth Geophyelos. ENSCO, inc in Springhold, Virginia is seeking a Program Manager Research Seismologist to Support an expanding program in solid earth goophysics. Research areas will include seismic network data processing associated with the detection, identification and location of natural and men-made seismic sources: earthquake characterization and source mechanism studies; explosion source charactorization; and ampilical studies using near field and far held seismic data. Experience in theoretical and observational seismology at regional and lefesoismic distances, is highly destrable. Experience m d-g-fal time series analysis is desirable. Ph.D. In soramology is highly desirable, however, M.S. level with experience in earthquake and explosion seesnology will be considered. Salary and benefits are extremely competitive. Resumes along with salary requirements should be submitted to the Personnel Department at the address below, Attention Code SAS, ENSCO, Inc., 5408-A Port Royal Road,

Equal employment opportunity: AAP,

Sedimentologist or Sedimentary Petrolo-gis/University of California, Santa Barba-ra. Applications are invited for a tenure track appointment in soft rock geology to be killed in 1981– 82. Rank dependent on qualifications and experi-ence but preference will be given to the assistant professor tevel. Applicant should normally have a Ph D. and strong field-orientation and quantitative background. The candidate will be expected to develop a strong research program in cleans eedi-mentation as related to basin analyses. The candidate will also be expected to teach at both undergraduate and graduate levels and interact with students and faculty of the department, particularly in the general areas of clastic diagenesis, volcanic processes, pateomagnetics, as well as field geology. Additional duties may include teaching physical geology and summer field geology. Please send resume, other documentation of additional and testing of teaching and the send to the commentation of additional and testing of teaching and the send to the commentation of the commentat graduate and graduate levels and interact with

abilibes, and four feiters of recommendation of abilibes, and four feiters of recommendation by August 31, 1981 to Dr. Arthur G. Sylvester, Chalman, Department of Geological Sciences, University of California, Santa Barbara, CA 93106, Telephone

The University of California is an affirmative ac-I on equal opportunity employer

Postdoctoral Research Associate Posihe Johns Hopkins University, Appited Physics Laboratory. Positions are available for studies of magnetospheric-lonospheric coupling, hydromagnetic waves, and plasma instabilities in the lonosphere and magnetosphere. The selected candidates will participate in the analysis and interpretation of data from spacecraft and ground-based radars as well as in the development and implementation of new ground-based and spacecraft studies. Positions are for one year and spacecrati studies. Positions are for one year and are renewable. Tenure may begin at any time through September 1, 1981. Applications should be addressed to Mr. Stoven F. Sayre, Dopt. ADI-15. The Johns Hopkins University, Applied Physics Laboratory. Johns Hopkins Road, Laurel, MD 20820.

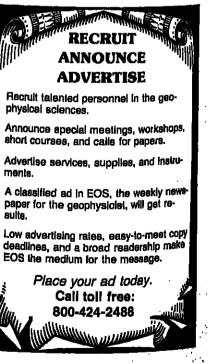
An equal opportunity employer, m.l.

Physical Oceanographer. The Pacific OCS Office. Bureau of Land Management, is seaking qualified candidates for a staff oceanographer to supervise contracted marine environmental research. The primary areas of research with the land to the contracted marine environmental research. lost oceanography and meteorology. Duties include serving as a contracting officer's authorized represerving as a contracting officer's authorized repre-sentative, developing study plans and work state-ments and advising management on matters within the candidate's area of expense. Grade level: GS: 9.11.12, salary \$16,885-26,951. Send a current \$F 171 by June 6, 1981 to Administrative Officer, Bu-reau of Land Management. 1340 W. Sixth St., Rm. 200, Los Angeles, CA 90017. For more information, call 213-888-7120. Mineralogy and Petrology. Applications are invited for a faculty position at Waeber State College, effective September 1981. This is a permanent faculty position with rank, salary, and tenure track status determined by qualifications. Responsibilities include teaching undergraduate courses in mineralogy, petrology, and geochemistry and some combination of mineral deposits, structural geology and introductory geology. Ph.D. preferred. WSC is a large (10,000 students) undergraduate college with a strong geology program graduating about 10–15 majors per year. The college is situated in northern Utah at the boundary between the Rocky Mountain and Great Bastn Provinces and adjacent to the Overthrust Belt. The Department is well aquipped for field-oriented teaching and research. The closing date for applications is July 1, 1981. Applications, including evidence of teaching proficiency and the names of three references should be sent to S. R. Ash, Chalirman, Department of be sent to S. R. Ash, Chairman, Department of Geology/Geography, Weeber State College, 3750 Harrison Bivd., Ogden, Ulah 84408. An equal opportunity/affirmative action employer,

Research Seismologist. The Alexandria Lab-oratories of Teledyna Geologist. from Ph.D.-level seismologists to work on problems related to the comprehensive and threshold test has treath resolutions. Applicants should have ban treaty negotiations. Applicants should have background in such topics as theoretical seismotopackground in such topics as theoretical seismoto-gy, seismic data analysis, seismic data gethering, advanced scientific computing, and computer sys-tems. To apply please send your resume to Jean Hill, Pesonnel Department, Teledyne Geotech, 314 Montgomery Street, Alexandria, Virginia 22314. An aqual opportunity employer. An aqual opportunity employer

Visiting Lecturar in Qeophysics. Geology Department seeks one year visiting lecturer 1981—82 to teach exploration geophysics and easiet with operation of earthquake laboratory (Includes WWSSN Station). Require Ph.D. or nearly completed Ph.D. Apply to the Geology Department, University of Montana, Missoula, MT 59812. Deadline August 1, 1981. Telephone (406) 243-2341.

Arizona State University, Department of Chemistry. Visiting professor, 1982–83 academic year or part thereof. We seek a person or persons with established research programs in geochemistry, mineralogy, petrology, and/or solid state chemistry to teach advanced apecial topics course(s), interact with faculty and studente, and pursue own research. May be an excellent sabbetical opportunity for established scientist. Contect: A. Navrotsky, Department of Chemistry, Arizona State University, Tempe, AZ 85281, (802) 965-4241. An AA/EO employer.



(All credit eard orders must be signed.)

search Position in Chemical Oceano phy. California institute of Technology. Division 6 ological and Planetary Sciences. The position of search fellow is being offered at Caltech for 18 search in oceanography, investigation of the isotopic composition of neodymium and rare earth abundances in sea water and sediments is now being carried forward. The mechanism of injection of REE into sea water will be studied. The differences in ¹⁴³Nd/¹⁴⁴Nd in various water masses [Piepgras al., Earth and Planet. Sci. Lett. 45, 223-236 and Plepgras and Wasserburg, Earth and Planst. Sci. Lett 50, 128-138 (1980)] is now being carried for ward as an exploratory venture in order to delermine the origin and chemical behavior of REE in the ocean and the potential use of ¹³Nd¹⁴Nd as a tracer. The laboratory facilities for sample preparation and analysis are fully functional and will be available. Applicants should have training in oceanography and a good perspective on general physi-

Send resume and references to Prolessor G. J. Wasserburg, Lunatic Asylum, California Institute of Technology, Pasadena, CA 91125. Calleon is an equal opportunity/affirmative action

UNOLS Executive Secretary

The University-National Oceanographic Laboratory System (UNOLS) is soliditing applications for an Executive Secretary, UNOLS is an organization of academic institutions for the coordination and pianning of oceanographic facilities, chiefly research vessels. The Executive Secretary administers the functions of UNOLS and heads the UNOLS Office which is located at and hosted by a Member laboratory. New office location is now pending, institutions which have signified an Intention to propose hosting the office

University of Delaware The Johns Hopkins University, Chesapeake Bay Institute Lamont-Doherty Geological Observatory of Columbia University University of Southern California, Institute for Marine and Coastal Studies University of Washington

Woods Hole Oceanographic Institution

It is anticipated that proposing institutions will negotiate with one or more applicants to become a part of their proposal, and selection will be based, in part, on the qualifications of the successful applicant who will become an employee of the host institution. Required qualifications include experience in oceanographic research and knowledge of research ship operations. Salary is negotiable depending on professional qualifications. Deadline for applications is July 31, 1981.

For further information, contact:

UNOLS Office Box 54P

Woods Hole Oceanographic Institution Woods Hole, MA 02543 (617) 548-1400, Ext. 2352

An equal opportunity employer M/F/H.



Physical Oceanographer: Memorial University of Newfoundland. Memorial University of Newfoundland in St. John's seeks to lill two scully positions in physical oceanography. One posilon is in ocean dynamics and the other is in theoretical oceanography. Interest and experience in carrying out field programs is desirable. Candidates for both positions should hold a Ph.D. in physical oceanography, or a closely related field (e.g. fluid mechanics).

The program in physical oceanography at Memorial University is new and offers the successful applicant an opportunity to participate in the develop-ment of this field in a frontier area. Memorial Uni-versity is located in St. John's, Newfoundland, which is rapidly becoming a centre of ocean studies related to fisheries and offshore hydrocarbon develpment in Eastern Canada.

Salary will be comment Applications, including curriculum vitae and the names of linee referees, are to be submitted to:

Department of Physics Memorial University of Newfoundland St. John's, Newf

Faculty Position/University of Alaska, Fairbanks. Applications are invited for a tenure track faculty position in economic geology in the Geology and provided the geology of the Geology of Geophysics Program to teach undergraduate and graduate courses in ore deposits, mineralogy, and exploration geology.

Applications should have demonstrated practical experience in release to the provided the geophysics of the provided that the geophysics is a provided to the provided that the provided the geophysics of the provided that the provid

experience in mineral exploration, regional and de-laied geologic mapping as well as a commitment to research in the genesis of ore deposits. The candidate will be expected to pursue a vigorous gradu-2's teaching and research program in economic geology with students primarily oriented toward ca-reers in the mineral industry.

Preference will be given to individuals with expe-nence in arctic or subarctic minerals research and a record of close collaboration with the mineral industry. Academic rank and salary commensurate with experience. Ph.D. required.

Send resume and three letters of reference Di-fector, Division of Geosciences, University of Alas-la, Fairbanks, Alaska 99701. Applications will be accepted until June 30, 1981, or until filled. The Linkspatie. The University of Alaska is an equal opportunity/ Sedimentologist-Sedimentary Petrogra-pher/Ohio State University. The department of Geology and Mineralogy invites applications for a tenure track faculty position in sedimentology-sedimentary petrography. The appointment is avail-able from August 1981. Salary and rank competitive and commensurate

with experience. Applicants should send resumes and names of at least three referees or address inquiries for further and Mineralogy, The Ohio State University, 125 South Oval Mall, Columbus, Ohio 43210. Closing date is July 1, 1981.
The Ohio State University is an equal opportuni-

ty/affirmative action employer

Seismology. Research associate position antic-Ipated (September 1, 1981), telemetry monitoring project in Virginia. Problems focus on seismichty and neotectonics in the state Prefer M S geophysicist with thesis in observational seismology, but others considered. Applications, transcripts and two Seismological Observatory, VPI&SU, Blacksburg. Virginia 24081. Deadline for receipt of applications : August 1, 1981. VPI&SU is an equal opportunity/affirmative action

Research Fellow/Sedimentary Geochemis try. The Australian National University invites applications for appointment as research fellow in sedimentary geochemistry, Research School of Earth Sciences. The School has a well equipped trace element laboratory, including an MS7 Spark Source Mass Spectrometer, with access to electron microprobe and XRD facilities.

The successful applicant should hold a Ph.D. de-gree and have a good background in geology, geo-chemistry, analytical chemistry, sedimentology and Pre Cambrian geology and should have experience in the use of the above analytical techniques.

He or she will be expected to participate in joint research projects dealing with the use of trace ele-

ment geochemistry in elucidating the composition and evolution of the Earth's crust through studies of

sedimentary rock sequences. In addition, applicants are invited to submit research proposals detailing the general research di-rections and specific projects which they would wish to pursue. Further information concerning the

position can be obtained directly from Dr. S R.

Applicants should submit a detailed curriculum vitae, a publications list and the names and addresses of three referees

Appointment as research fellow will be up to three years in the first instance with the possibility of extension to five years. Salary range: \$A19132 to \$A24972 per annum (\$A1 = \$US1.14). Superan-

The University reserves the right not to make an appointment or to make an appointment by invitation at any time.

Applications should be sent to The Registrar, The Australian National University, PO Box 4, CANBERRA, ACT 2600, AUSTRALIA by 3 AU-

Biogeochemist or Organia Geochemist. Research assistant protessor with interest in organic matter cycling in coastal sediment systems, as part of interdisciplinary group. Academic year appoint-ment with opportunity for renewal. Resume, names of three references, and letter of research interests by July 1 to L. Mayer, Ira C. Darling Center, Univer-sity of Maine at Orono, Welpole, Maine 04573. Equal opportunity/affirmative action employer

Crustal Selsmology: Princeton Univer-sity. Candidates with an interest in any of the fol-lowing are invited to apply for research staff ap-

Marine seismic data analysis and struc-

Marine solsmit data sharps and sharps and sharps and cean margins.
 Narrow and wide angle reflection seismology applied to continental crustal geology.
 Wave propagation theory and techniques.

of asismic data analysis. Princeton University has an ongoing program for the creative reanalysis of existing multichannel reflection data—such as COCORP and USGS ofshore data Special projects are undertaken from time to time to collect field data in critical areas or to test new methods of data collection and analysis A high performance 32 bit minicomputer system for data analysis and theoretical work is to be installed

1.1

Applicants should send curriculum vitee and a list of three references to:

Robert A Phinney Department of Geological and Geophysical Princeton University Princeton, NJ 08544 Or inquire: 609-452-4118 Date of appointment and salary are negotiable Princeton University is an equal opportunity em-

Consejo Nacional de Investigaciones Cientificas y Técnicas

CHIEF OCEANOGRAPHER

A postdoctoral scientist with several years experience in physical oceanography is required at IADO (Instituto Argentino de Oceanografia), a joint Institution of the Consejo Nacional de Investigaclones Científicas Y Técnicas (National Research Council), the Universidad del Sur, Bahía Blanca, and the Armada Argentina (Argentine Navy).

The applicant, in addition to research and postgraduate teaching in his own field, will also be responsible for the planning, coordination, and supervision of activities in other branches of oceanography at large.

The position is under the auspices of a joint program of the Consejo Nacional de Investigaciones Científicas y Técnicas (CONI-CET) and the Interamerican Development Bank (IDB). It will be initially of medium duration, and is renewable.

It will be located at Bahia Blanca. Salary and fringe benefits according to qualification. Knowledge of Spanish language will be considered an advantage. For consultations or submitting applications, contact:

Señor Presidente del Consejo Nacional de Investigaciones Clentificas y Técnicas Avda. Rivadavia 1917 (1033) Buenos Aires, Argentina.

Applications should include complete academic and professional background along with a list of publications as well as names and addresses of three references.

AGU

New Member Sponsors

One hundred sixty-six members were elected between March 31 and April 30, 1981. The AGU members who sponsored them are listed below. Earlier lists were published March 24 and April 28.

Three Members: Robert B. Smith. Two Members: M. S. T. Bukowinski, David S. Chapman, Robert A. Duncan, Bryan L. Isacks, Charles M. Keeler, LaVerne D. Kulm, James S. McClain, Forrest Mozer, W. J. Raitt, Thomas C. Royer, and Donald U. Wise.

One Member: Thomas J. Ahrens, Walter Alvarez, Don Anderson, James G. Anderson, Kinsey A. Anderson, Moha Ashour-Abdalla, Steven Bachman, George E. Backus, Fred Baker, Steven C. Bergman, Dale Bibes, Sveinbjorn Bjornsson, Ross A. Black, D. L. Blackstone, Jr., Gillings D. B. Bott, Gunnar Bodvarsson, Frances M. Boler, Martin H. P. Bott, E. Boyle, L. W. Bralle, Randolph W. Bromery, Charles A. Brott, Robert C. Brown, R. L. Bruhn, Roger G. Burns.

Robert S. Carmichael, Mingten Chang, Charles R. Chapcell, R. J. Clegg, John W. Clough, Ron M. Clowes, Charles E. Contain E. Corbato, Charles S. Cox, Richard G. Craig, Kenneth M. Creer, Geoffrey F. Davies, Paul M. Davis, Howard W. Day, Paul S. DeCarli, Robert E. Dennis, Steven R. Dickman, F. A. Donath, H. James Dorman, Leroy M. Dorman, Charles L. Drake, Richard E. DuBroff, Fred Duennebler. Dieter H. Ehhalt, David S. Evans, Hans P. Evgster, Leon-

ard S. Fedor, Michael Fehler, Robert W. Ferguson, Henry F. Filegel, L. Nell Frazer, F. A. Frey, A. Shelby Frisch, T. J. Fitzgerald, Joseph Frizado, Cliff Frohlich, Kazuya Fujita, Michael O. Garcia, Ronald J. Glbbs, Freeman Glibert, R. W. Girdler, Billy Price Glass, Ambrose Golcoechea, Melvyn L. Goldstein, Paul Greisman.

Frank Hadsell, Gregory D. Harper, C. G. A. Harrison, Halstead Harrison, Larry A. Haskin, Gary E. Hauser, Craig O. Hayenga, John G. Heacock, Hugh C. Heard, Robert A. Helliwell, Thomas L. Henyey, W. J. Hinze, Kenneth J. Hollett. Thomas E. Holzer, Jose Honnorez; Lonnie L. Hood, Robert Houtz, Robert L. Huguenin, Ru J. Hung, Anthony Irving, E. Irving, H. M. Iyer, Ansel G. Johnson, T. H. Jordan,

JoAnn Joselyn Douglas L. Kane, M. Allan Keys, Charles D. Keeling, George H. Keiler, W. Kertz, Raz Khaleel, Carl Kisslinger, Peter K. Kitanidis, Jan Kouba, Led Kristjansson, Arthur F. Kuckes, Andre S. Kusubov, Helmut E. Landsberg, Bjorn T. Larsen, Edwin E. Larson, B. E. Leake, Darrell I. Leap, Conway B. Leovy, Joel S. Levine, J. G. Liou, Austin Long, Daniel P. Loucks, Allen Lowrie, William J. Ludwig, Alan M. Lumb, Timothy M. Lutz.

William D. MacDonald, R. M. MacQueen, Thomas Maddock, James Magill, David C. Major, Stephen D. Malone, Murii H. Manghnani, Robert Mark, Bruce D. Marsh, David L. Martin, Russell McDuff, Michael B. McElroy, L. D. McGinnis, Stuart McHugh, Randolph Moberly, Walter Mooney, O. B. Moore, Dennis Wilson Moore, H. J. Morel-Seytoux, Helmut Montz, L. J. Patrick Multier, Patricia E. Murtha. Frederick Nagle, Manuel Nathenson, Richard S. Naylor, David L. Nebert, Anthony Nekut, F. M. Neubauer, Shlomo P. Neuman, R. W. Nicholis, Henry Joseph Nelbauer, Richard W. Nightingale, Hallan C. Noltimier,

W. P. Olson, Richard E. Orville, Benjamin M. Page, Donald F. Palmer, Chung Park, Robert L. Parker, David F. Paskausky, Bryan Pearce, Henry Perkins, K. A. Pfitzer, John A. Philipolis, Morris B. Pongratz, Raymond A. Price, Ivar B. Ramberg, Joseph B. Reagan, Charles R. Real, David L.: Reasoner, Irwin Remson, Eugene D. Richard, John D. Richardson, Randall M. Richardson, Robert E. Riecker, Peter A. Rigotti, Peter Rogers, William M. Roggenthen, William B. Rossow, Peter H. Roth, Jacob Rubin, David Rusch, Sidney L. Russak.

Rafael Sanchez, Kim David Saunders, Samuel M. Savin, David W. Saxton, Marc L. Sbar, Kenneth F. Scheidegger, John William Schlue, Ulrich Schmidt, Robert W. Schunk, David Seidemann, Stephen Seif, Margaret Ann Shea, Gordon G. Shepherd, Peter N. Shive, Loren Shure, John M. Sinton, George L. Siscoe, Charles W. Slaughter, David B. Slemmons, Don F. Smart, Douglas L. Smith, Eugene I. Smith, Scott B. Smithson, Charles P. Sonett, Frank Spera. R. R. Steeves, Daniel B. Stephens, J. Carl Stepp, Robert G. Stone, William D. Stuart, Desiree E. Stuart-Alexander,

Peter Styles, Steven T. Suess, Kendall L. Svendsen. Pradeep Talwani, Michael A. Temerin, Ta-liang Teng, H. R. Thierstein, Ronald J. Thomas, T. R. Toppozada, Donald L. Turcotte, Petr Vanicek, Kenneth L. Verosub, Thomas A. Vogel, Etstratios G. Vomvorls, Carl A. Von Hake, William B. Wadsworth, Harve S. Walf, Mary Emma Wagner, Clyde Wahrhaftig, Raymond J. Walker, C. Wang, Steve Wegener, Ray F. Weiss, J. E. White, John M. Wilcox, James G. Williams, John Wilson, W. P. Winn, I. J. Won, David D. Wooldridge, Francis T. Wu, Shi Tsan Wu, Klaus Wyrtki, Gour-Tsyh Yeh, Hsueh-Wen C. Yeh.

Meetings

Applied Glaciology Symposium

The International Glaciology Society has slated its second meeting on the applied aspects of snow and ice research for August 23-27, 1982, at the Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire. This Second Symposium on Applied Glaciology will include technical sessions on the engineering problems of floating ice; engineering problems of ground ice; icebergs and glaciers; properties and behavior of snow and ice; snow removal and control; avalanche control and snow pressure; ice accretion; and modeling techniques in applied

For additional information, contact the Secretary General, International Glaciological Society, Lenslield Road, Cambridge CB2 1ER, United Kingdom. o

Coastal Engineering Conference

The 18th International Conference on Coastal Engineering, will be held November 14-19, 1982, in Cape Town, Ropublic of South Africa.

Topics to be covered at the conference include wind current and wave action; tides and long waves; sedimentary processes and coastal morphology; estuary and inlet behavior; coastal structures and recreational facilities; ship motions and harbor entrance design; ocean outfall design and construction; and environmental aspects of coastal en-

Five copies of a synopsis (not to exceed two pages) of papers proposed for the conference should be sent to Billy L. Edge. Secretary, Coastal Engineering Research Council, Department of Civil Engineering. Clemson University. Clemson, SC 29631. Deadline is October 31, 1981.

Underwater Mining Institute

The 12th Underwater Mining Institute is scheduled for October 20-22 in Madison, Wisconsin. The program will include presentations on mineralogy of marine sulfide deposits; tectonic setting for spreading center sulfide deposits; seafloor sullides in the Galapagos and other Pacific areas; new developments in southeast Asia offshore tin operations; geophysical techniques for finding underwater copper lodes; new geochemical techniques for marine minerals exploration; changes in the international mining trade of relevance to marine mining; and the impact of sea grant minerals research on industry. The program will also include tours to local research laboratories.

For registration information, contact Gregory Hedden, Sea Grant Advisory Services, University of Wisconson, 1815 University Avenue, Madison, WI 53706 (telephone: 608/262-0644)

For technical program information, contact J. Robert Moore, Marine Science Institute, University of Texas, P.O. Box 7999, University Station, Austin, TX 78712 (telephone: 512/471-4818). 6.

AGU Midwest Meeting

September 17-18 Minneapolis, Minnesota

Abstract Deadine: July 1 Convenor: V. Rama Murthy

Papers and posters originating in or pertaining to the region are solicited for the following special ses-

Mantle structure and dynamics. Contact Geoffrey Davies or Clem Chase.

Rock water interactions: Hydrothermal processes and metallogenesis. Contact William Seyfried. Precambrian crustal evolution of the North American continent. Contact Paul Weiblen.

Geomagnetism and paleomagnetism. Contact Subir Banerjee

Hydrology in the mid-continental U.S. Contact H. O. Plannkuch or E. C. Alexander, Jr.

Use standard AGU format (see page 20 of January 13 Eos) and send original and two copies of abstracts to AGU Midwest Meeting, 2000 Florida Avenue, N.W., Washington, D.O. 20009. Abstracts will be oublished in Eos, with a substantive meeting report after the meeting. There will be no abstract charge

Aquifer Protection Policies

A special program entitled 'Effects of New Aquifer Protection Regulations and Policies on Ground Water Management' will be held at the American Society of Civil Engineers' Spring Convention and Exhibit during the week of April 19, 1982, in Las Vegas, Nevada. The program is sponsored by the Hydraulic Division's Committee on Ground Water Hydrology and by the Environmental Englneering Division's Committee on Hazardous Waste Man-

A call for papers has been issued for the following topics: review of regulatory activity, future protection regulations. and policies; groundwater quality monitoring; design of well networks; groundwater studies stemming from regulations, including remedial measures; and ongoing and needed research. Research topics should address pollution sources, transport and fate of pollutants, methods of detection, and aquifer rehabilitation.

Geophysicists interested in presenting a paper should send a one-page abstract to Richard J. Schicht, Illinois State Water Survey, 605 East Springfield Avenue, P.O. Box 5050, Station A, Champaign, IL 61820 (telephone: 217/333-2594). Deadline is July 31, 83

Workshop on Remote Measurement of **Underwater Parameters**

This workshop was held at Bolkesjø, Norway, October 30 to November 1, 1980. It was arranged by the Royal Norweglan Council for Scientific and Industrial Research, Space Activity Division; Institute of Geophysical Research, University of Bergen; and Office of Naval Research, Arlington, Viria. Il was sponsored by the Royal Norwegian Council for Scientific and industrial Research, the North Atlantic Treaty Organization, and the Office of Naval Research.

One may conclude from the meeting that the idea that it may be possible to determine any subsurface variables of the ocean by remote sensing is attractive in principle, but realizable now, in a severely limited manner, and still possible of advancement. Sound waves are now used for tracking SOFAR floats to map out deep and mid-level currents, and acoustic tomography offers possibilities that are now being explored in the field, with the first tentative results now being reported. Acoustic tomography measures a combination of velocity and sound speed fields over the water column, and the data can be interpreted to give mean variables and a number of integral measures of water properties as well as statistical measures of the field of variables. The upper mixed layer is not so well sampled by acoustic tomography, so for the upper layer, one will have to rely upon other methods. In saltwater, electromagnetic waves cannot be used profitably; for brackish or fresh water overlying salt water, radar monopulse methods offer some promise. Such methods are in routine use for ice pr on lakes and rivers, and extension to estuaries may prove useful and practical.

Satellite interrogation of drifters, and shore station tracking of drifting buoys are other methods of obtaining information about the ocean without having to go there each time one wants information.

Among the active methods of sensing variables in the upper ocean are ground wave and ionospheric scatter radar. The ground wave radar method, one example of which is CODAR, when used from shore, can sense the current field in the upper 1/2 meter of the ocean with a spacial resolution of 1.5 km² and 0.10 m/s. While a few examples were given of synthetic aperture radar (SAR) signatures in SEASAT-SAR data, the processing algorithm was not described in sufficient detail to enable one to make any judgement about the method, although in principle it should be possible to Infer current along one direction from Doppler-shifted reflections. The SAR data also show a strong correlation between bathymetry and sea surface roughness. As at previous workshops where these data have been preented, there was little, if any, analysis given of the dynamles of the processes. The active optical methods, using laser light sources, take advantage of the following effects:
the Rayleigh scattering broadens the spectral width, and the broadening is temperature dependent. Thus, one may be able to measure temperature by observing the reliected light from pulsed, range-gated lasers,

ST. \$30 (1)

Next comes Raman backscatter for measurements of 82 linity, temperature, and other variables, and then comes Brillouin scattering to sense sound velocity. When a very Intense laser signal hits the water, it will also heal it and generate an acoustic signal. The reflection of the acoustic signal back to the surface (by density structures) will in the generate a measurable surface signature. One can use the for depth sounding from airplanes and, ultimately, from even more remote platforms. The combination of possible ties, although few of them are now at a stage ready for routine practical use, suggests that one should follow develop ments closely. The methods, so far, seem to be mainly useful in the upper 50 m of the ocean but may some day be extended to several times that depth. This will tell us very little about the deeper water column. But the possibility of obtaining synoptic data, even in the upper few melers, seems interesting. The technology needs to be worked out and the oceanographic community need not yet hold its collective breath and sit around and wait, but the new methods may be upon us in a few years. The active and passive remote sensing of water properties has, of course, also been extended to sensing of biological properties. Here the workshop contained a very interesting set of papers on algorithms and the inverse problem and an example of application of color measurement to mud flat and lical flat properties.

The first paper was by N. K. Højerslev, who showed that different regions of the ocean have sufficiently different plankton-related color that a universal algorithm for interpreting color in terms of biological measures will have sellous shortcomings. The next paper, by J. Fischer and H. Grassi, who had examined the problem of remote sensing of particulates, found that the problem of determining particulate matter variables from color observations was not well conditioned and that the matrix really had only two linearly independent characteristic vectors. The tentative conclusion of this listener to these two papers was that before one can use color to determine biological variables, one needs to introduce some information about local biological properties as a constraint on the Inversion process. This means that one needs biologists to help with the interpretation; one cannot find a way where the technology system and the computer can do it all by themselves. This should not be a source of wonder because blology is a nonlivial branch of science and cannot be left to automation. One has to develop a certain judgement and expertise before one can produce useful results.

The Coastal Zone Color Scanner provides useful information for biologists, but the information from the intensity of color bands cannot be used blindly, it has to be interpret ed through the use of knowledge about local biology as a constraint on the inversion process. An example of how to Incorporate local knowledge in an inversion problem was given by Prober, Bahr, and Dennert-Muller, who interpreted the LANDSAT images from different channels, in terms of tidal flat classes, including dry sand, wet mud, and others by using 'training fields' and in situ establishment of field characteristics. The use of these training fields introduced the local constraint on the inversion process and made it possible to classify a large region from LANDSAT data at ter field work in a limited area that covered the important classes of flats.

This is apparently the direction in which one has to seek methods for interpreting upper ocean color. Also, no doubt. the same method can be used with active sensors, where one senses the color quality of reflection of laser lights from different depths, including fluorescence effects.

While some of the methods seemed kind of far from practical realization in the near future, there is rapid technology development under way.

The workshop was informative for the participants, and the sober assessments provided by the working groups showed that one cannot dismiss remote sensing techniques out of hand, that the technologists need to encount ter scientists to learn what one should look for, and it showed how one may adjoin specialist knowledge to remote sensing data. In that sense the workshop was educe tional, realistic, and productive of sober evaluations of methods. An abstract volume will be available shortly in the state of the Royal Norwegian Council for Scientific and Industrial Research, Space Activity Division, P.O. Box 309, Blinden, Gaustadallen 30 D, Oslo, 3, Norway.

This meeting report was prepared and submitted by Eik Mollo-Christensen of the Department of Meteorology and Physical Oceanography at MIT, Cambridge. S

> For Your Convenience and More Rapid Service

Call Toll Free 800-424-2488

You Can Now

Place book orders

Market Britain

• Change your mailing address • Inquire about AGU services

VISA & Master Card charges are welcome Orders over \$50.00 may be billed (postage & handling costs will be added).

If you are charging your purchase, please have your charge card ready when you call. Calls answired 9 a.m.-4:30 p.m. E.S.T. from anywhere in the continental U.S.A.

Geophysical Year

(Boldface indicates meetings aponsored or cosponsored by AGU.)

May 27-29 Canadian Meteorological and Oceanographic Society 15th Annual Congress, Saskatoon, Saskatchewan, Canada. (B. E. Goodison, Program Chalrman, Atmospheric Environment Service. 4905 Duferin Street, Downsview, Ontario M3H 5T4

June 1-4 First JECSS Workshop Tokyo. Japan. Sponsor, Tsukuba University. (Takeehl ichiye, Dept. of Oceanography, Tex-88 A&M University, College Station, TX

June 1-5 Second International Symposium on inertial Technology for Surveying and Geodesy, Banff, Canada. Sponsors, AGU, Canadian Institute of Surveying, Univ. of Calgary. (Klaus-Peter Schwarz, ISS Symposium 1981, Division of Surveying Engineering, Univ. of Calgary, Calgary, Alberta T2N 1N4 Canada.)

lune 3-4 Symposium on the Ecology and lanagement of Reservoirs, Université Laval, Quebec, Canada. Sponsors, Unesco, Université du Quebec, Université Laval, Hydro-Quebec, Societé d'Energie de la Baie James. (P. G. C. Campbell, Univeraité Quebec, INRS-Eau, C.P. 7500, Ste. Fov. Quebec G1V 4C7 Canada.)

June 4-5 Eastern Snow Conference, Syracuse, N.Y. (B. E. Goodison, Program Chairman, Atmospheric Environment Ser vice. 4905 Dufferin Street, Downsview, Ontario M3H 5T4 Canada.)

June 7-11 Eighth Ocean Energy Conference for the Department of Energy, Washington, D.C. Sponsor, Marine Technology Society. (Harry Irwin, Marine Technology Society, 1730 M St., N.W., shington, DC 20036.)

June 8-10 International Geoscience and Remote Sensing Symposium, Washington D.C. Sponsors, AGU, IEEE Geoscience and Remote Sensing Society (F. T. Ulaby, Remote Sensing Laboratory, Univ. of Kansas Center for Research, Inc., West Campus, Lawrence, KS 66045.)

June 14-19 Second International Confer ence on Urban Storm Drainage, Urbana, III. Sponsors, Univ. of Illinois, International Liaison in Urban Storm Drainage, International Association of Hydraulic Research, International Association of Water Pollution Research, American Society of Civil Engineers. (B. C. Yen, Department of Civil Engineering, Univ. of Illinois, Urbana, IL 61801.)

June 15-19 International IEEE/APS Symposium, National Radio Science Meeting, and international IEEE/MTT Symposium. Los Angeles, Calli. (Prof. N. G. Alexopoulos, 7732 Boelter Hall, Department of Elecirical Sciences, Univ. of California, Los Angeles, CA 90024.)

lune 22-26 International Symposium on Erosion and Sediment Transport Measurement, Florence, Italy. Sponsors, IAHS, Inemational Commission on Continenta Erosion, National Research Council of Itay. (P. Tacconi, Secretary of the Organiz-Committee, istituo di Ingegneria Civile Via S. Marta, 3 50139 Firenze, Italy.) June 23-26 Seventh International Symposium on the Machine Processing of Remotely-Sensed Data, West Lafayette, Ind.

Sponsor, Laboratory for Applications of Remote Sensing, Purdue Univ. (D. B. Mor-rison, Purdue Univ./LARS, 1220 Potter Dr., West Lafayelle, IN 47906.) June 24-26 International Symposium on

Real-Time Operation of Hydrosystems, Naterico, Ontario, Canada. Sponsor, Water Resources Group, Univ. of Waterloo. (T. E. Unny or E. A. McBean, Univ. of Walerioc, Department of Civil Engineering, Waterloo, Ontario N2L 3G1 Canada.) June 29-July 2 22nd United States Sympo-

slum on Rock Mechanics, Cambridge,
Mass. Sponsor, Massachusetts Institute of
Technology. (Barbara Dullea, Coordinator,
Center for Advenced Engineering Study
Seminara, MIT, Cambridge, MA 02139.)
June 29-July 3. Conference Marketon pp. June 29-July 3 Conference/Workshop on Helerogeneous Catalysis—Its Importance to Atmospheric Chemistry, Albany, N.Y. Sponsors, NSF, NASA. (V. A. Mohnen, Atmospheric Sciences Boscorch Center. mospheric Sciences Research Center, State Univ. of New York, Albany, NY

June 29—July 11 Seminar on Fluid-Dynamical Problems in Astrophysics and Geophysics, Chicago, Ill. Sponsors, American Mathematical Society, Society for Industrial and Applied Mathematics. (Meeting Arrangements Department, American Mathematical Society, Post Office Box 6248, Providence, R.I.)

uly 6-11 Geocongress '81-South African Geodynamics Project and 3rd international Platinum Symposium, Preforia, South Africa. Sponsors, Geological Scolety of South Africa, South African National Committee for the international Union of Geological Sciences. Sciences, Society of Economic Geologists.
(The Symposium Secretariat S. 217, CSI)3,
P.O. Box 395, Pretoria 0001 Republic of South Africa.)

July 8-10 National Conference on Environmental Engineering, Atlanta, Ga. Sponsor, Environmental Engineering Division of American Society of Civil Engineers. (F. Michael Saunders, 1981 National Conference on Environmental Engineering, School of Civil Engineers, Georgia Institute

of Technology, Atlanta, GA 30332.) July 15-17 Summer Computer Simulation Conference, Washington, D.C. Sponsors, Instrument Society of America, the Society for Computer Simulation. (William E. Buchanan, Applied Physics Laboratory,

Johns Hopkins Road, Laurel, MD 20810.)
July 21–23 Chapman Conference on
Spatial Variability in Hydrologic Modeling, Fort Collins, Colo. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

July 21-30 21st General Assembly of IA-SPEI, London, Ontario, Canada. (A. E. Beck, Department of Geophysics, Univ. of Western Ontario, London, Ontario N6A 6B7 Canada 1

July 27-30 Eighth International Symposlum on Urban Hydrology, Hydraulics, and Sediment Control, Lexington, Ky. (Don J. Wood, Department of Civil Engineering, 208B Anderson Hall, Univ. of Kentucky, Lexington, KY 40506.) Aug. 3-15 IAGA Fourth Scientific Assembly, Edinburgh, United Kingdom. (B. R.

Leaton, Institute of Geological Sciences, Edinburgh EH9 3LA United Kingdom.) Aug. 4-7 International Conference on Energy Education, Providence, R.I. (Donald Kirwan, Conference Chairman, Office of Energy Education, Univ. of Rhode Island,

Kingston, RI 02881.) Aug. 9-15 Symposium on Variations in the Global Water Budget, Oxford, United Kingdom. Sponsors, ICCL, IAHS, INQUA. (Prof. R. E. Newell, Department of Meteorology, 54-1520, MIT, Cambridge, MA 02139.1

Aug. 9-18 International Congress of Surveyors, F.I.G., Montreux, Switzerland. Sponsor, Fédération Internationale Des Geometres. (American Congress on Surveying and Mapping, 210 Little Falls Street, Falls Church, VA 22046.)

Aug. 10-14 International Conference on Basement Tectonics, Oslo, Norway. Spor sor, Norwegian Petroleum Society. (Roy H. Gabrielsen, Department of Geology, Univ of Oslo, P.O. Box 1047, Blindern, Oslo 3 Norway; or Don L. Baars, Department of Geology, Fort Lewis College, Durango, CO 81301.)

Aug. 10-14 Water Forum '81: Technical State of the Art Exchange, San Francisco, Calif. Sponsors, American Society of Civil Engineers, Irrigation and Drainage Division, Committee on Drainage. (P. M. Meyers, 509 North Roosevelt Blvd., Apt. D-105, Falls Church, VA 22044.)

Aug. 10-19 20th General Assembly of the International Union of Radio Science, Washington, D.C. (R. Y. Dow, National Academy of Sciences, 2101 Constitution Ave., Washington, DC 20418.)

Aug. 17-28 Third Scientific Assembly of IA-MAP with Extraordinary General Assembly, Hamburg, Federal Republic of Germa ny. (S. Ruttenburg, NCAR, P.O. Box 3000, Boulder, CO 80307.)

Aug. 17–18 Open Symposium on Mathe-matical Models of Radio Propagation, Washington, D.C. Sponsor, URSI. (J. R. Walt, Bidg. 20, Electrical Engineering Department, Univ. of Arizona, Tucson, AZ 85721.)

Aug. 17-22 Ninth International Symposium on Earth Tides, New York, N.Y. Sponsors, IAG, IUGG, Columbia Univ. (J. T. Kuo, 828 S.W. Mudd, Columbia Univ., New York,

Aug. 18-21 Second Biennial Conference and Exhibition of the Australian Society of Exploration Geophysicists, Adelaide, South Australia. (J. Haigh, Conference Chairman, P.O. Box 42, Unley, South Australia 5061.) Aug. 20-21 Second International Sympo-

sium on Computer-Alded Selsmic Analysis and Discrimination, North Dartmouth, Mass. Sponsors, Electrical Engineer Department, Southeastern Massachusetts University, IEEE Computer Society, IEEE Acoustics, Speech and Signal Processing Society. (C. H. Chen, Electrical Engineering Department, Southeastern Massachusetts University, North Dartmouth, MA

Aug. 24-26 International Symposium on Management of Geodelic Data, Copenhagen, Denmark, Sponsors, IAG, the Danish National Committee of IUGG, Geodaetisk Institut. (C. C. Techerning, International Symposium Management of Geodetic Data, Geodetick Institut, Gamiehaye Alle 22, Charlottenlund DK-2920 Denmark.)

Aug. 24-29 Eighth Annual Meeting of the European Geophysical Society, Uppsala, Sweden, (C.-E. Lund, Chairman Local Organizing Committee, Institute of Solid
Earth Physios, Uppsala University, Box
558, 22 Uppsala; Sweden.)
Aug. 25-27 The Royal Institution of Char-

tered Surveyora Centenary Celebration, London, England. (Representative Rad-London, England. (Representative Rad-linski, American Congress on Surveying and Mapping, 210 Little Falls Street, Falls Church, VA 22048.). Aug. 28—Sept. 9 Aro Volcanism Sympo-sium, Tokyo, Japan, Sponsors, Volcano-logical Society of Japan, IAVCEI. (Datsuke

Shimozuru, IAVECEI Symposium on Arc Volcanism, Earthquake Research Institute. Univ. of Tokyo, Bunkyo-ku, Tokyo 113 Ja-

Aug. 31-Sept 2 Third International Colloquium on Mars, Pasadena, Calif. Sponsors, NASA, Lunar and Planetary Institute Division of Planetary Sciences of the AAS. (Conway W. Snyder, Jet Propulsion Laboratory, Pasadena, CA 91109.)

Aug. 31-Sept. 5 Symposium on Geodelic Networks and Computations, Munich, West Germany. Sponsor, IAG. (Deutsche Geodätische Kommission, Bayerischen platz 8, D-8000 Munchen 22.)

Sept. United Nations Symposium on Water Management in Industrialized Areas, Lis-bon, Portugal. (Chairman of the Executive Committee, international Symposium on Water Management in Industrial Areas, Portuguese Water Resources Association. c/o LNEC, Av. do Brasil, 101, 1799 Lisbon, Portugal.)

Sept. 7-12 Third International Symposium on Antarctic Glaciology, Columbus, Ohio. Snow and ice, international Glaciologica Society. (Institute of Polar Studies, Ohio State Univ., 125 S. Oval Mail, Columbus, OH 43210.)

Sept. 8-12 American Society of Photogrammetry-American Congress on Surveying and Mapping Fall Convention, San Francisco, Calif. (L. W. Aggers, USGS, 345 Middlefield Road, Mail Stop 31, Menio Park, CA 94025.)

Sepi. 13-17 National Water Well Associa tion 33rd Annual Convention and Groundwater Technology Education Session, Kansas City, Mo. (NWWA, 500 West Wil-

son Bridge Rd., Worthington, OH 43085.) Sept. 16-18 Oceans '81, Boston, Mass. Sponsors, Marine Technology Society. IEEE Council of Oceanic Engineering, AGU. (R. Nagle, Publicity Manager, Raytheon Company, 141 Spring St., Lexington, MA 02173.) Sept. 17-18 Midwest Meeting, Minne

apolis, Minn. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.) Sept. 17-18 Pacific Northwest Regional Meeting, Ellensburg, Wash. (Bob Bentley, PNAGU, Central Washington University, P.O. Box 1000, Department of Geology, Ellensburg, WA 98920)

Sept. 20-22 National Water Well Association 34th Annual Convention and Exposition, Atlanta, Ga. (NWWA, 500 West Wilson Bridge Rd., Worthington, OH 43085.) Sept. 28-Oct. 10 NATO Advanced Study Institute on Chemistry of the Unpolluted and Polluted Troposphere. Corfu, Greece. (W. Jaeschke, Center of Environmental Protection, University of Frankfurt, Robert

Maver-Str. 11, 6000 Frankfurt/Main, FRG.) Oct. 6-8 International Conference on Time Series Methods in Hydrosciences, Burling ton, Ontario. Sponsors, National Water Research Institute of the Canada Centre for Inland Waters and Water-Resources Branch of Ontario's Ministry of Environ ment. (A. El-Shaarawi, Aquatic Physics and Systems Division, NWRI, Canada Centre for Inland Waters. P.O. Box 5050. Burlington, Ontario L7R 4A6 Canada.)

Oct. 11-14 Coastal Society's Seventh Annual Conference, Galveston, Tex. (N. West, Coastel Society Conference, Department of Geography and Marine Affairs, Univ. of Rhode Island, Kingston, Ri

Oct. 11-15 51st Annual International Meeting of the Society of Exploration Geophysiclats, Los Angeles, Calif. (William L. Baker, Technical Program Chairman, c/o Chevron Oil Field Research Co., Box 446, La Habra, CA 90631.)

Oct. 13-15 Fifth Geogressured-Geothermal Energy Conference, Baton Rouge, La. Sponsors, Louislana Geological Survey, Department of Natural Resources; Energy

Programs Office, Louislana State Universily; U.S. Department of Energy. (Ann Bachman, Conference Coordinator, Energy Programs Office, 105 Hill Memorial, Louislana State Univ., Baton Rouge, LA 70803.) Oct. 13-16 Division of Planetary Sciences of the American Astronomical Society An-

nual Meeting, Pittsburgh, Pa. (B. Hapke, Dept. of Geology and Planetary Science, 321 Old Engineering Hall, University of Pittsburgh, Pittsburgh, PA 15260.)
Oct. 14-16 Third Surveying and Mapping Colloquium for the Petroleum Industry, Banfi, Alberta, Canada, Sponsor, Canadian Petroleum Association. (Liz Hampton,

633 Sixth Ave., S.W., Calgary, Alberta. Canada T2P 2Y5.) Oct. 22-24 Fourth Conference on the Physics of the Jovian and Saturnian Magnetospheres, Laurel, Md. Sponsor, NASA. (S. M. Krimigis, Applied Physics Laboralory, Johns Hopkins Univ., Laurel, MD

Canadian Petroleum Association, 1500.

Oct. 26-30 Symposium on Quaternary Land-Sea Migration Bridges and Human Occupation of Submerged Coastlines, La Jolla, Calif. Sponsors, Quaternary Shorelines Commission of the International Union for Quaternary Research, Scientific Committee of the World Confederation of Underwater Activities. (Patricia M. Masters, Scripps Institution of Oceanography,

A-012, La Jolla, CA 92093.) November 1-5 Sixth Bionnial International Estuarine Research Conference, Gleneden Beach, Oreg. Sponsor, Estuarine Research Federation. (Jay F. Watson, Treasurer, USFWS Suite 1962, 500 N.E. Multnomah Street, Portland, OR 92232.) Nov. 2-6 International Conference on the Venus Experiment, San Francisco Bay Area, Calif. Sponsor, NASA. (Dr. Lawrence Colin, Ames Research Center, Molfett

Field, CA 94035.) Nov. 9-11 Special Conference on the Mechanical Behavior of Salt, University Park. Pa. Sponsor, Rock Mechanics Laboratory Department of Mineral Engineering, Pennsylvania State University, (H. Reginald Hardy, Jr., Rock Mechanics Laboratory. Room 117, Mineral Sciences Building. Pennsylvania State University, University

Park, PA 16802.) Nov. 9-20 Second Symposium on Geodesy in Africa, Nairobi, Kenya. Sponsors. IÁG. IUGG Local Committee of Kenya. IUGG Committee on Advice to Developing Countries, African Association of Cartography. (R. Omandi, Survey of Kenya, P.O.

Box 30046, Nairobi, Kenya.) Nov. 30-Dec. 11 43rd Session of the International Statistical Institute, Buenos Aires, Argentina. (Jim R. Wallis, IBM, Research Division, Box 218, Yorktown Heights, NY 10598: or G. S. Watson, Bernoulli Society for Mathematical Statistics and Probability Department of Statistics, Princeton Univ., Princeton, NJ 08544.)

Dec. 3-5 Topical Conference on the Processes of Planetary Rifting, San Francisco, Calif. Sponsor, Lunar and Planetary Institute. (Rift Meeting, Projects Office, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058.) Dec. 7-11 AGU Fall Meeting, San Fran-

cisco, Calif. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.) Dec. 18-19 Annual International Meeting of the Working Group on Mediterranean Ophiolites, Florence, Italy. (Luigi Beccaluva, Istitulo di Petrografia, Via Gramsci 9,

Geodynamics Series Volume 1



Dynamics of **Plate Interiors**

43100 Parma, Italy.)

Editors: A. W. Bally, P. L. Bender, T.R. McGetchin, & R. I. Walcolf

An interdisciplinary investigation focused on 4 major

areas of study: Instrumental Measurement of the Deformation of Piote Interiors History and Mechanism of Plateaux Uplifi Vertical Movements from the Stratigraphic Record Quaternary Vertical Movements

This final report of the international Geodynamics Project, Working Group 7 on Geodynamics of Plate Interiors, brings together a variety of papers dealing with the nature and origin of the dynamics of the more stable regions of the earth.

> Copublished by the Geological Society of America . 164 pages / \$15.00 Hardbound / 20% member discount

\$50,00 musi be prepaid American Geophysical Union 2000 Florida Avenue, N.W. Washington, D.C. 20009 Call 800-424-2488 Toll free

1982

Jan. 11-14 Symposium on the Understand-Ing of Hydrologic Processes at the Basin Scale, Caracas, Venezuela, Sponsors, Universidad Simón Bolivar, IAHS. (Ignacio Rodríguez-Iturbe, Universidad Simón Bolívar, Apartedo Postal 80.659, Caracas 1081 Venezuola l

Feb. 8-12 Third International Geodetic Symposium on Satellite Doppler Positioning, Las Cruces, N Mex. Sponsora, Defense Mapping Agency, National Ocean Survey, AGU. (Richard Peat, Defense Mapping Agency, Hydro-graphic Topographic Center, 6500 Brooks Lane, N.W., Washington, DC 20315.)

Feb. 16-19 Ocean Sciences: AQU/ ASLO (American Society of Limnolegy and Oceanography) Joint Meeting, San Antonio, Tex. (Meetings AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

Mar. 22-26 International Symposium on Hydrothermal Reactions, Yokohama, Japan, Sponsor, Tokyo Institute of Technology. (Shigeyuki Somiya, Research Laboratory of Engineering Materials, Tokyo Institute of Technology, Nagatsula, Midori, Yokohama, 227 Japan.)

Apr. 11-16 Penrose Conference on Anlarctica, Shenandoah National Park, Va. Sponsor, GSA. (lan W. D. Daizell, Lamont-Doherty Geological Observatory, Columbia University, Pallsades, NY 10964.)

April 19-21 Cordiferan Section, Geological Society of America and Seismological Sci cioty of America Annual Meeting, Anaheim, Calif. (Nell Maloney, Earth Science Dopartment, California State Univ., Fullorton, CA 92634.)

May 3-7 14th international Liege Colleguium on Ocean Hydrodynamics, Liège, Belgium. Sponsors IAPSO, Unosco Marine Sciences Division, EGS, Intergovernmental Oceanographic, AGU. (Jacques C. J. Nihoul, University of Liège, Mecanique des Fluides Géophysiques Environment, 86- Sart Tilman, B-4000 Liège, Bolgium.)

May 7-20 General Meeting of IAG, Tokyo, Japan. (I. Nakagawa, Geophysical Instilule, Kyolo University, Sakyo-ku, Kyolo 606 Japan.)

May 10-12 Fourth International Conference on Planning and Management of Water Resources for Industrial, Agricultural, and Urban Use, Marseilles, France. Sponsors. Commission Europeenne Mediterranéenne de Planification des Eaux (C.E.M.P.E.), Société des Eaux de Marseille (S.E.M.), the Bureau de Recherches Géologiques et Minières (B.R.G.M.), Centre de Formation Internationale à la Gestion des Ressources en Eau (CEFIGRE), UNESCO. Commission des Communautés Européennes, Association des Hydrogéologues (AIH). (Secretariat de la Conference, Societe des Eaux de Marseille, 25 rue Edouard Delanglade—13008 Marseille, France)

May 24-June 4 International Solar-Terres-Irial Physics Symposium, Ottawa, Ontario, Canada. (Professor Liu. University of Illinois, Urbana, IL 61801.1

May 24-June 4 24th Plenary Meeting of COSPAR Ottawa, Ontario, Canada, (Dean Kastel, Space Sciences Board, National Academy of Sciences, 2101 Constitution Ave., N.W., Washington DC 20418.)

May 25–28 Symposium on the Composition of Nonurban Troposphere Williamsburg, VA. Sponsors, AMS, NASA AGU. (Jack Fishman, Mail Stop 401-8, NASA Langley Research Center, Hampton, VA 23665.)

May 31-June 4 AGU Spring Meeting. Philadelphra, Pa. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, OC

June 13-17 International Symposium on Hydrometeorology, Denver, Colo. Sponsor, American Water Resources Association. (A. I. Johnson, Woodward-Clyde Consullants, 2909 West 7th Ave., Denver, CO

June 15-18 International Conference on Rainwater Cistern Systems, Honolulu, Hawali, Sponsors, University of Hawaiis Waler Resources Research Conter. AGU. (Yu-Si Fok, General Conference Chairman, Water Resources Research Center, Univ. of Hawaii, 2540 Dole Street. Honolulu, HI 96822.)

June 27-July 2 Fifth International Conference on Geochionology, Cosmochronology, and isotope Geology, Nikko National Park, Japan. (K. Shibata, Geological Sur-voy of Japan, Higashi 1-1-3, Yalabe, Ibaraki 305 Japan.)

July 19-30 Scientific Meeting of IAHS with Extraordinary General Assembly, Exeter, United Kingdom. (John C. Rodda, Department of the Environment, Water Data Unit, Reading Bridge House, Reading RG1 8PS

United Kingdom.)
Aug. 2-13 Joint Oceanographic Assembly, Halifax, Nova Scotla, Canada, Sponsor, Scientific Committee on Oceanic Research. (Leo O'Quinn, National Steering Committee for JOA, c/o Canadian Commit tee on Oceanography, 240 Sparks St., Ot-laws, Onlario K1A 0E6 Canada.)

Aug. 15-21 Fourth International Symoosium on Antarctic Earth Sciences, Ingle Farm, South Australia, Australia. Spon-

sors, Australian Academy of Science, Austrattan Academy of Technological Sciences, International Union of Geological Sciences, Scientific Committee on Anlarctic Research, Geological Society of Austra-lia, Inc., Univ. of Adelaide. (J. B. Jago. South Australian Institute of Technology P.O. Box 1, Ingle Farm, South Australia.

Australia 5098.) Aug. 15-22 International Meeting on Generation of Major Basalt Types, Reykjavik, Iceland, Sponsors, IAVCEI, IAGC. (Basal Meeting, c/o G. E. Sigvaldason, Nordic Volcanological institute, 101 Reykavik, iceland.)

Aug. 15-22 IAVCEI and IAGC Joint Meeting, Reykjavik, Iceland. (G. E. Sigvalda-son, Nordic Volcanological Institute, Univ. of Iceland, Geosciences Building, 101

Aug. 22-28 11th International Congress on nentology, Hamilton, Ontario, Canada. Sponsor, IAS. (IAS Congress 1982, Department of Geology, McMaster Univer-sity, Hamilton, Ontario LBS 4M1, Canada.)

Aug. 22-28 Third Circum-Pacific Energy and Mineral Resources Conference, Honofulu, Hawaii. Sponsor, IUGS. (AAPG Convention Department, P.O. Box 979, Tulsa, OK 74101.)

Aug. 23-27 Ninth Annual Meeting of the European Geophysical Society, Leeds, United Kingdom. (J. C. Briden, Department of Earth Sciences, University of Leeds, Loods LS2 8JT, England.)

Aug. 23-27 Second Symposium on Applied Glaciology, Hanover, N.H. Sponsor, International Graciology Society. (Secretary General, International Glaciological Society. Lensfield Road, Cambridge CB2 1ER, United Kingdom.)

Sept. Third International Kimberlite Conference, Clermont-Ferrand, France. (Francolse Boudier, Université de Nantes, Laboratoire de Tectonophysique, 2 Rue de la Houssiniere, 44072 Nantes, France.) May or Sept. Scientific Meeting of IAPSO.

Oceanic Consultants, P.O. Box 7325, San Diego, CA 92017.) Dec. 6-10 AGU Fall Meeting, San Francisco, Calif. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

Halifax, Canada. (E. C. LaFond, LaFond

July 18-23 Fourth International Conference on Permafrost, Fairbanks, Alaska, Sponsors, National Academy of Sciences, State of Alaska, (L. De Goes, Polar Research Board, National Academy of Sciences, 2101 Constitution Ave., N.W., Washington, DC 20418.)

Aug. 15-26 18th General Assembly of IUGG, Hamburg, Federal Republic of Germany. (P. Melchior, Observatoire Royal de Belgique, Avenue Circulaire 3, B-1180 Bruxelles, Belgium.)

Aug. 27 Symposium Commemorating the 100th Anniversary of the Mount Krakalau Eruption, Jakarta, Indonesia. Sponsor, Indonesian Institute of Sciences. (Didin Sastrapradja, Deputy Chairman for Natural Sciences, L1P1 JL, Teuku Chik Ditiro 43, Jakarta, Indonesia.)

Sept. 12-14 National Water Well Associa-Von 35th Annual Convention and Exposition, St. Louis, Mo. (NWWA, 500 West Wilson Bridge Rd., Worthington, OH 43085.) Dec. 5-9 AGU Fall Meeting, San Francisco, Calif. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

FUTURE AGU MEETINGS

Fall Meetings December 7-11, 1981, San Francisco December 8-10, 1982, San Francisco December 5-9, 1983, San Francisco

May 31-June 4, 1982, Philadelphia

AAPG American Association of Petroleum Geologista AMS American Meteorological Society ASCE American Society of Chemical Engi-

GSA Geological Society of America IAG International Association of Geodesy IAGA International Association of Geomagnetism and Aeronomy

IAHS International Association for Hydrological Sciences IAMAP international Association of Melecrology and Atmospheric Physics
IAPSO international Association of Physical

Sciences of the Ocean IASPEI International Association of Seismology and Physics of the Earth's Interior AVCEI International Association of Volcanology and Chemistry of the Earth's Interi-

IUGS International Union of Geological Sci-IWRA International Water Resources Associ-

MSA Mineralogical Society of America SEG Society of Exploration Geophysicists SEPM Society of Economic Paleontologists and Mineralogists URSI International Union of Radio Science;

Separates

To Order: The order number can be

GAP

found at the end of each abstract; use all digits when ordering.

Cost: \$3.50 for the first article and \$1,00 for each additional article in the same order. Payment must accompany

Deposit Account: A minimum of \$10.00 may be placed on deposit with AGU for the purchase of separates. I funds are on deposit, the cost of the first article is only \$2.00 and \$1.00 for each

additional article in the same order.

Separates will be mailed within 3 weeks of journal publication or within 10 days if ordered after the journal has appeared. Separates are available for purchase for two years from date of

Copies of English translations of articles from Russian translation journals are available either in unedited form at the time of their listing in EOS or in final printed form when a journal is published. The charge is \$2.00 per Russian page.

Send your order to: American Geophysical Union 2000 Florida Avenue, N.W. Washington, D.C. 20009

Hydrology

Jiid Erosion and Sedimentation
UNSTRADY ONE-DIMENSIONAL SETTLING OF SUSPENDED
CENTUREST
S. Dhanotheron, J. S. Guillwer, H. G. Stefan
(St. Anthony Falls Hydraulic Laboratory,
University of Minnesota, Minnespolis, Minnesota

university of Minnesota, Minnespolis, Minnesota 55414)

A con-dirochional, unsteady numerical codel for the vertical distribution of suspended sodiront concentration and tate of suspended sodiront description in shallow water stirred unifornity has been developed. The suvection/diffusion aquation is solved by a fully implicit, especially in the substitution are unconditionally stable respections of Feclet number Pa = Vh/D, where V = particle fail velocity, h = depth, and D = vertical turbulent exchange conflictent. The model is presented; effect critoris for selection of depth and line steps are given. A comparison between a numerical solution and an exact analytical solution is given for an instantaneous injection. A generic study of suspended mediment concentration profiles as a function of depth and two and for various Pecifet numbers has been need and results are given in damentalness graphical form. Esuspended sediment, numerical graphical form.

Il10 Erosion and Sadimentation
(MARKL INSTABLITY IN A BRAIDEO, SAND-BED RIVER
M.L. Gref (Department of Geography, Arizona State
University, Tempe, Arizona, 8528)

The Gila River of countral Arizona is representative of braided, sand-bed rivers in alluvial
veillays that have inherent unstable behavior and
destructive channel signation. The 112-year
record of channel conditions along a portion of
the Gila River provides data for the construction
of locational probability maps for main-flow
channels. Zones of stability and hazardous instability alteracts with each other at 3.2 km
(2 mi) intervals. Ouring the past century, the
overall sinusity of the main flow channel has
remained close to 132 despite numerous thanges in
subreaches as a result of sedimentation bablind a
dam and fluctuations in the density of phreatophyte growth, which both affect the hydraulics
of flood flows. Unstable zones of the channel
correspond to the surface of the sediment wedge
behind the dam and areas dense phreatophyte
growth. Stable zones correspond to areas controlled by bedrock or man-made structures, as
well as locations determined by these external
factors plus the requirement to maintain a consistent situosity. Channels such as that of the
Gila River do not neet most assumptions of aquisibrium, and are best understood through probabilistic approaches with an assumption of
catestrophic adjustment. (Fluvial processes,
phreatophytes, braided channels).

Mater Resour. Res., Papor 19096

3125 Claciology A DETAILED STUDY OF SNOW ACCUMULATION AND STABLE SOTOPE CONTENT IN THE DOME C (ANTARCTICA) J. R. Petit (Laboratoire de Gisclologie, CNRS 2, rue Très-Ciofires, 38031 Grenable Cedex France) J. Jousel, M. Pourchet and L. Merliva

during the 1955-1965 period. This conclusion is supported by measurements over a large geographical sector of East Antarctica.

Shortar term changes of the snow accumulation have been studied by various means and in particular from detailed deuterium contest profiles; by comparing with the beta and tritium radioactivity determinations it is shown that the deuterium variations do not sallow to obtain a seasonal vacord. In such a low accumulation area different mechanisms, such as smoothing of the isotopic signal, roughness of the surface, irregularity of the accumulation which may disturb the short iterm record are discussed.

The interpretation of stratigraphic observations is not straightforward, However it was possible to obtain a calibration down to the 1955-layer which silows to offer a deling of saces layers over the last 100 years. The mean accumplating a obtained (3, 7 g/, cm*/yr) is ti good agreement with the value of season and the said of measures.

mints, Congraphical changes of the magn deute-rium content are relatively small showing that.

las hava been taken in the

Snow samples have been taken in the Dome C area with the purpose to study the variations of the accumulation rate and of the stable isotope content over the last century. Stakes observations indicate a large spatial variability of the accumulation rate at one year scale (or 2.6 g/cm²/yr) for a mean value a 3.6 g/cm²/yr). The depth of the 1965 and 1955 layers determined from beta radioactivity means account to the latest the content of the latest the latest the latest the content of the latest the content of the latest the lates The depth of the 1965 and 1955 layers determined from beta ratioactivity measurements in 19 altes allows to deduce that the spatial variability bactomes small at an year scale (a = 0.3/cm² per year) abowing that the snow collected at one point is well representative of the fallen pracipitation over this period. The rate of snow accumulation since 1965 is about 10% higher than during the 1955-1965 period. This conclusion is supported by measurements over a learn

The macroscopic differential equation of the mane, linear momentum, and emergy belove for groundwater are derived from First principles by using the methods of statistical mechanics.

at a ten scale the isotopic signal is well representative of the mean deuterium content of the precipitation. This ensures that the smoothed (ten years running mean values) deuterium profile obtained over the last 160 years provides a good indication of the temperature secular trend in the Dome C area (Snow accumelation, stable isolopes in snow, snow strati graphy, radioactive fallout) J. Goophys. Res., Grean, Paper 100715

3130 Groundwater
TRANSPORT OF ION-EXCHANGING SOLUTES IN GROUNDMATER! CHROMATULRAPHIC THEORY AND FIELD SIMULATION

TION
A. Valorchi, R. Street (Department of Civil Engineering, Stanford, California 94303) and
P. Roberts
Equations describing the transport of ion-exchanging solutes governed by local chemical equilibrius through a saturated porous modium are well established in the literature. Concentration the general multi-species equations typically ex-hibit unusual and complicated features, such as multiple fronts and plateau zones. This paper presents an analytical framework, based upon the theory of chromotography, which permits a pri-characterization of cortain key concentration profile features. The cases studied include both homovalent and heterovolont exchange in binery and terrary systems. In order to tast its vali-ity, the chromatographic analysis is applied to a field project involving direct injection of a vanced-treated municipal offluent into an aquif-all of the major features observed in the avail-able field data are accurately predicted by the chromatographic theory. (Groundwater, ion-ex-change, thromatography, oprova padius) change, thromatography, porous medium), Vater Resour, Res., Paper 100717

3130 GIDUNGWALET \ COMPARISON OF THE INCOMPLETE CHOLESKY-CONJUGATE GRADIENT METHOD WITH THE STRONGLY IMPLICIT METHOD AS APPLIED TO THE SOLUTION OF TWO-DIPENSIONAL GROUPS-WATER FLOW EQUATIONS
L. K. Kuiper (U.S. Goological Surve",
Huron, South Dakota 57750)
This paper commares the efficiency of
the strongly implicit procedure (SIP)
and the incomplete Cholesky-conjugate
gradient method (ICCG) suppled to the
solution of the finite-difference approximating equations for geoundwater flow.
Results for five isotropic two-dimensional test problems are prosented. Thrus
are limaar confined-aquifer croblems, and
two are nonlinear water-table aquifer
problems; in all but one of the test
problems; in all but one of the test
problems the aquifer was considered to
be no-homogeneous. Both SIP and iCCG as
applied to water-table acquifer problems
were varied for each of the test problems
to reduce the amount of computational
work needed to find a solution. ICCG was
usually substantially more efficient than
SIP when applied to the confined-aquifer
test problems. For the water-table
aquifer test problems, SIP and iCCG verformed equality well.
Water Resour. Res., Paper 190716 ATER FLOW EQUATIONS

Paul A. Withorsmoon Charges, a Berkeler Laboratory and Department of Materials Science and Bharel Englacering, University of California, Berkeler, 942201

19420)
Laboratory studies on field flow in single fractures in rock sumples up to a neter in size auggest that there is a definite problem of scale. Two such studies have been reported, but the results are not consistent. The sandingly controdictory results may simply be a menifor tation of the offects of fracture surface rough name. A basic problem in attempting to understand the physics of fluid (low in fracture is that of understanding the elicate of surface roughness. The invostigations that are savissioned to attack this problem will only be possible on rock samples that are such larger than the conventions) size. Seophys. Res. Luct., Peper LLO624

3130 Groundwater BTEADY PERIODIC FLOW THROUGH A RECTANGULAR DAM J.H. Knight (Division of Machamatics and Statistics, CSIRO, P.O. Box 218, Lindfield, NSI 2070, Australia)

2070, Australia)
To unsteady free surface flow through a rectangular procus dam, a simple relation which
compacts a pressure integral with the movement
of the free nurface is derived. For steady
periodic movement driven by oscillating reservoir
levels, the time average of the pressure integral
leads to an average discharge formula which is a
generalization of the Dupuit-Forchheimer
discharge formula. For periodic fluctuations of
groundwater in a shellow constal squifer in
response to ridel oscillations, it is show that
the equilibrium free surface level for from the sea is equal to the root mean square of the sea level, independent of the validity of the Osputz-Porobhalmer assumptions used by Philip-(Groundwater flow, free surface, Deputz-Forchheimer theory, tidel effects). Mater Resour. Rus., Paper 190499

3130 Groundweter
AMALYSIS OF FLOW THROUGH HETEROGENEOUS RANDOM
AQUIFERS BY THE NETHOD OF EMBEDDING MATRIX.
PART 1: STEADY FLOW
G.Dagen(Schoold of Engineering.Tel-Avty University

G. Dagan(Schoold of Engineering Tel-Aviv University Tel-Aviv, Israel)
The statistical structures of the hydraulic conductivity, head gradient, specific discharge and head fields are enalyzed with the aid of a simplified model consisting of a collection of spherical (in three dimensions) and cylindrical (in two dimensions) blocks of different conductivity and diameter set at random and independently in space. Results of a previous work for effective conductivity and unbounded formations (Ougan, 1979) are recovered and given a rational derivation. The influence of the equifer boundary and oppuniform average flows are examined for the first time. The growth of the head variance with distance from boundary in two-dimensional flows is compared with that of Monte-Carlo simulations of Smith and Freeze (1979).
Mater Respur, Rem., Paper 80W1014 Water Resour, Res., Paper SOW1014

OFGUNGWALLET
THE STATISTICAL MECHANICAL THEORY
OF CROCKOMATER FLOW
O. Sponico (Dept. of Soll and Environ. Enlances
Oniversity of California, Riverside 92521)
S.-Y. Chu

Broundwater are derived from first principals by using the methods of statistical exchanger. The resulting mecrospopic equations agree with those derived recominy on the basis of fluid mechanics and local volume averaging, except in the mean of energy behaven. The beliefs equations for total and internal energy is groundwater are analyzed in detail; it is shown that the groundwater internal energy is actually a paperial specific incornal energy is actually a paperial specific incornal energy is actually a paperial specific incornal energy as a travitational fluid, whereas the time development is affected by a travitational fluid, whereas the time development is energy of groundwater valuement of the total energy of groundwater whereas the first is appeared to the measurement of the medical principal equation of incornal paters. The law of the medical party is appeared to grant the flow equation.

INSO Precipitation
TOBE LIMITING FORMS OF THE POISSON DISTRIBUTION
OF ANNAL STATION PRECIPITATION
OF ANNAL STATION PRECIPITATION
P. 1. Engleson (Massachusetts Institute of
P. 2. Engleson (Massachusetts Institute of
P. 3. Engleson (Massachusetts Institute of
Rebusioly: Cambridge, Massachusetts Institute of
Rebusioly: Cambridge, Massachusetts Institute of
Annal station precipitation a represented as
assoniength, number of storms, and storm depth,
saroniength, number of storms, and storm depth,
sard the distribution of the annual total is
derived. The contribution of each constituent
arrights to variance of the annual total procipitation is determined and limiting distributions
of the inter are derived by letting each contribution vanish separately. In humid climates,
it is shown that the storm depth variability
predominates giving a distribution which is
closely normal. In artic climates, the number of
storm controls and gives a highly-skewed distribution. All cases are compared with observations.

Water Resour. Res., Paper 140249

3160 hydrology: Run-off and streemflow OFTERNIKATION OF THE CONFIDENCE INTERVALS OF THE WATER DISTRIBUTION USING ORDER STATISTICS.

8. Robbe (intervatise du Québec, INRS-Eau, C.P. 7500, Ste-Foy, Québec, Canada) P. Boucher Recent results show the interest of the Wakeby distribution to raprasent fluod flows. It is possible to daterwine in an explicit fashion the distribution of the order statistics for the Wakeby distribution. The determination of the confidence intervals for a given level of an event of return period T is daduced when the Wakeby distribution is fitted to a sample of size in this peakers procedure is valid for all estimation methods of the parameters of the Wakeby distribution and gives a good approximation.

**Mater Rasseur, Ras., Paper 180243

MAD Except and extraction

SSIMATION OF EXTREME LOW FLOWS FOR PURPER
SSORAGE RESERVOIR DESIGN

A. V. Maccalte [Department of Engineering
Rathematics, The University, Newcastle upon Tyne,
Angland and J. A. Macdaley

A mathod for estimating the probability of
con-exceptance of low flows for a reservoir fed
directly by one tiwer with additional pumpad
leflow from a second river is described. The
mathod is based on the joint probability
distribution of an extreme value distribution
and a runcated extreme value distribution. The
satinates of the probabilities of given low
flows are given by laregates. These are
valuated numerically for a reage of low flows
at a structure daily pumping retex. Details are
given for the particular case of total inflow
dating a three consecutive month poriod, but
the bathod could be used for any duration.
How flows, reservoir, pumped atorage, joint
youtability distribution.)
Fiter Resour. Res., Paper 140655

3160 Runoff and stroumflow ECHOVAL FLOOD FROQUERCY ESTIMATION AND NETWORY DESIGN Fail P. Greis and Eric F. Wood (Department of Clvf) Ingineering, Princeton University, Princeton, 81 78121

The use of probability weighted moments has been insestigated for improving estimates of flood recovered questile events in both gauged and ungauged tasins. Pagional estimates at gauged situs are in-proved over more conventional methods such as method fromests and maximum likelihood estimation. An improved established rungauged basins is proposed which interpretes both probability weighted moment tochniques with more traditional mean peak flow estimation. The question of network design in terms of scarce is such as a mamber of years of record in terms of the stability weighted as each tachiques, (natwork design, regional flood in page 7) probability weighted a constant

itto Runoii and stream how yee McOPELS FOR FLOOD LEVEE DESIGN

i. k. Tung (Dept. of Clivil Engr., University of Nevtis, Reno, Nevada) and L. W. Mays (Department of
Creil Engr., University of Texas, Austin, Texas),
be the design of flood leves systems there are many
grameters and variables with associated uncertantes. This paper presents models which systemstically analyze the various types of uncertainties in
the hydrologic aspect as well as hydraulic aspect of
design and enalysis to define the risk and reliability of
co-entopping. Both static and time dependent risk
rades are developed. Results show that risks evolused by the simple return period method can be
recreasing distribution model used. The risk-safety factor relationships are shown to be very sensitive to the
hydrologic loading probability model adopted, so that
canposite models are suggested for risk enalysis,
Vatar Seaour, Res., Paper 190502

NY) Runoff and streamflow CATURE NETURE NETURE AND THE DIAMETER-MAG-SITE RELATION

1. Jarvis (Daparement of Geography, State University of New York at Buffelo, 415 Froncask Hell, 2dfalo, New York 14260) and C. Shem Drainage network attructure can be described in term of elongation or compaction, using the network diseaser and magnitude. The relation stocan natwork dismater and magnitude. The relation stocan natwork dismater and magnitude at the Coologic squivalenc of the well-known relationship between mainstress longth and drainage basin stem. Dismater increases with pagnitude, but at decreasing acquivalence of the well-known relations in the state of the state of the sample of relationships of different stems. The stream is not random. Large cributeries pre-copt inside the sample of the ttram. Vater Resour. Res., Paper 190477

1170 Enow and ice PRACTINE METRANICAL MODELS OF DRY SLAB AVALANCES BILFAST

FIGATE PREVANCEL MODELS OF DRY SLAB AVALANCHE PIEFAT
Forld N. Retlang (Division of Building Rassarch, Fallonal Tassarch Council, 1906 that 4th Avenus, Vancorer, 2.C. V6g 195
Laperimental avidence shows that smow is a prastore smoothing. Statement of the smoothing transfer smoothing the smoothing transfer smoothing to the smoothing transfer in a weak layer material in alow, compant rate, shown dispressed in the statement of the smoothing transfer release it hypothesised to be possible with or without statement in the smoothing transfer in the statement of the smoothing programming friture with or even strong the smoothing to the smoothing to the smoothing transfer in the smoothing transf

3175 Foll coleture
1980/20 Lines Thial Function Finite ELEMENT
1980/20 Lines Thial Function Finite ELEMENT
2.v. Broades II and O.L. Copper (School of California, Irvine, Capacity)
5. 22717]

Milly

The alternation theore is used together with
the artical field metion - Galerin finite eleinear tital function - Galerin finite eleproperative exacts formulation to develop
forward the transfer formulation to develop
forward the transfer finite alternative
to students methods. Secondly, this approach
tip for element entries and the indexity of the second methods are the second transfer
to students of the second methods.

The second methods is a second transfer
the second methods are the second transfer
the second methods are the second transfer
to a second method transfer
the second method trans igr. Mas., Paper BOWL690

3175 Boil moiscure CAMOPY TEMPERATURE AS A CROP WATER STRESS

1175 Bott moiscure
CAMOPY TEMPERATURE AS A CROP MATER STRESS
(MRICATOR
R. D. Jackson (U. S. Warer Conservation
Laboratory, 4318 B. Brondway Rd., Phoenix,
Aritona B5040), S. B. 16so, R. J. Raginato, and
P. J. Pinter, Jr.
Canopy temperatures, obtained by infrared
thermometry, along with war- and dry-builb air
temperatures and an estimate of net radiation
were used in equations derived from energy
balance considerations to calculate a crop warer
temperatures and an estimate of net radiation
were used in equations derived from energy
balance considerations to calculate a crop ware
termas index (CMEI). Theoretical limits were
destinate an related to the sit waper pressure
deficit. The CMF1 was shown to be aqual to 1 E/F2, the ratio of actual to potential ewaper
transpiration obtained from the Fansan-Hontshith
equation. Four experimental plots, planted to
wheat, tracelwed post-margence irrigations at
different times to create different degrees of
water stress. Partinear veriables were measured
between 1340 and 1400 seach day (secopt some
weekends). The CMF1, plotted as a function of
time, closely paralleled a plot of the estractable soil water in the 0- to 1.1-n mone.
Usefulness and limitations of the lower entime, closely paralleled a plot of the estractable soil water to the 0- to 1.1-n mone.
Usefulness and limitations of the lower endiacussed. (Water stress, soil todature, plant
cenopy temporature, infeared thermometry).
Water Resour. Bea., Faper 190449

3175 Soil Moleture
STATISTICAL ANALYSIS OF THE BROOKS-CORFY AND THE
GREFN-ANT PARAMETERS ACROSS SOIL TRETURES
R. F. RéCuen, W. J. Rawis (USD-3-HA, Building OOZ,
BAC-Wast, Beltaville, Keryland 20705) and
D. L. Brakensiak
Infiltration is a major component of the hydrologic cycle for most watersbade. Therefore, it
is important to have a mathod that can provide
infiltration extinates for mole within ungaged
watershade. Both the analysis of verlance and
the multivariate analysis were used to execute
whether extinated Brooks-Corsy and Green-Aspt
parsmelers differ singularly or collectively
across soil taxture classes. The snalysis indicated that the parameters for the two module answined varied collectively across soil testure classes. Meas parameter values and stendard arrors for soil testures are presented for

NAME ARROUF. RES., Paper 190476

3175 Soil mojeture
TWD-DIMENSIONAL SOIL HOISTURE FLOW IN A SLOPING
RECTANGULER SOIGHON, EXPERIMENTAL AND MANGERICAL
STUDIES
J. L. Nieber (Department of Agricultural Engithering, Texas A&H University, College Station,
Texas 77843) and H. F. Malter
Results from experiments with a 3.66 meter by
0.38 meter by 0.108 morer flunc filled with sind
are used to study the two-dimensional flow of
soil mojeture under the condition of reinfall infiltration. The maperimental results are coopered
to results obtained by a unserted solution (vie
a linite slement-finite difference transformation)
of the two-disquasional Sichards equation. The
results are presented in the form of flow itself
conditions (hydraulic head distribution and position of the phreatic surface) and the rising link
of the runoff ladrograph. The experimental and
the numerical results are in merisfactory agracment when the affect of capillary hystoresis is
incorporated into the numerical solution. When
capillary hystoresis is ignored the numerical intention of the phreating of the behind the apparimentally derived hydrograph.
[50] copillary hystoresis,
Mater Resour, Res., Paper 190596

APPORTIONMENT OF NET RECHANGE IN LANDFILL COVERING LAYER INTO SEPARATE CONTUNENTS OF VERTICAL LEAFAGE

AMD MORIZONTAL SELPACE
John J. Lentz (Johns Mophics University Applied
Physics Laboratory, Laurel, Maryland 20810, USA:
Surplus soil moisture in a sloping laudfill coexing leyer to apportioned into a vertical leshage
fraction and a horisontal sespage fraction by assuning vertical itoe squal to the hydraulic conductivity of the waste and Darcian horisontal flow
through a varyling vertical cross-section at a velocity determined by the hydraulic conductivity of
the cover laver and a gradient equal to the slope
of the interface between the cover layer and the of the interface between the cover layer and the wante. The governing equation is may up by input output analysis, and differentiates into the Boussinse equation. The resulting partial differential equation to solved by linearization. A

NETAL 10M CONCENTRATIONS ASSOCIATED WITH LATE SUMMER SEDIMENTS OF THE ORIO RIVER H.T. Spencer (Department of Chemical and Environmental Engineering, Speed Scientific School, University of Louiswille, Louiswille, Kantucky, USA; C.A. Lauchart, and R.S. Colyer The fine late aumner andiments of the HcAlpine pool of the Obio liver are described as composed of an average 32 by dry weight volatile solids material. The volatile solids component was found to be associated with virtually all of the COD, hydrogen, sodium, potassium, aumneances, and lead, se well as a significant fortion of the carbon, chronium, iron, copper, and zind. Magnasium was found to have all of its sead shell component seasofized with the non-volatile portion of the sedment. The sobiant therium and cranium concentration was found to be 11.0 i 0.5 and 1.4 2 0.5 ug s , respectively. The potential effect of this late summer sediment on suttle (first as suggested. (Metal ione, river sadiments, Ohio Siver).

3190 Instruments and techniques SIMPLE IN-SITU DETERMINATION OF STURAULIC COMMUNITARY BY POWER-FUNCTION DESCRIPTIONS DRAIMAGE She-Kong Chong, Richard E. Green (Mewaii Institute of Tropical Agriculture and Homan Rasources, and Mater Resources Research Center, University of Hewaii, Homojulu, Navsit) and

University of Hewaii, Homojulu, Hewaii) and La jac R. Ahaja Equations for calculating bydraulic conductivity functions (6) and K(h), where Ø is volumetric water content and h is sail water pressure head, were derived with the assumption of unit bydraulic predient. The derivation of unit bydraulic predient. The derivation may be power functions to describe the change in Ø and h with time during the redistribution pariod following standy infilteration. The unit gradient assumption was found to be satisfied during intermediate stages of derimage but not at certy and lare times (i.e. high sod low water contents). However, derivations from unit gradient did not cause serious errors in the calculated conductivity on the test soils, well drained existed which evidence a decrease in conductivity with depth at field seturation (Hydraulic conductivity, unsaturated coils, intiltration, drainage, oxisols, soil water machods). machoos; . Mater Resour, Ros., Paper 190656

.3190 Mydrology - Instruments and techni-A SURVEY OF NATHEMATICAL OPTIMIZATION AND MODELS AND ALGORITHMS FOR DESIGNING AND EXTENDING IRRIGATION AND MASTEMATES NET-

EXTENDING INRIGATION AND MASTERIAL MORKS.
Christoph E. Handl (Institute for Advanced Studies; Studesrases &; A-1050 Viehna, Austria)
This parer presents a state-of-the-art survey of network models and shorithms that can be used as a blanking kool in irrigation and wastewater systems. It is irrigation and wastewater systems. It is shown that the problem of designing or shown that the problem of designing or excepting such systems, beginning or the same type of mathematical outsides time model. The difficulty in splving time model lies mainly in the properties of the objective, function, Trying to ninion the objective function. Trying to ninion a construction and/or operating costs of a system typically results in a construction of the constr

economies of scale. A number of vavo to attack such models are discussed and compared, including linear organization, integer programming and specially designed exact and heuristic algorithms. The usefulness of each emprach is evaluated in terms of the validity of the noise, the commutational completity of the algorithm, the properties of the solution, the evaluated for the solution, the swalthlistic of software and the constilling for sensitivity analysis. (Ontinization, unraws, integrating usasteratem). Nater Resour. Nes., Espec 180325

3199 General or miscellaneous THE IRRIGATION SCHEDULING PROBLEM AND EVAPOTRANSPIRATION UNCERTAINTS A.E. Rhomalo, R.L. Braz (Massi

A.E. Bhemale, Rt., Bree (Massachusetta joetfute of Tachology, Cachridge, Rassachusetts O2119)
Scheduling and determining irrigation water applications is an important consideration given idnited water resources and increasing concorn about agricultural productivity. Past literature has repeatedly been concerned with the influence of the variability of actual evapotranspiration on crop irrigation conder. This work investigates the above issue. A rode, based on Stochastic Dynaolc Programing, is formulated to taxinise set benefits from a crop facing ancortain, correlated, ovepotranspiration dramnds. Workly irrigation decisions are unde after observing current soil polature and available irrigation water, as well as potential evapotranspiration in the past weak. The todel is similar to the traditional reservoir control significant popular in the surface water literature. A cape study evapote indicates that although the nodel formulation is useful and feasible, the offect of uncertain evapotranspiration on regigation parformance reasures is apparently minimal. (Irrigation, auspotranspiration, dynamic programing).

programing). Vator Ruscur, Res., Paper 180731

1990 denoral or miscellaneous nydrology
THE EFFECT OF CVID WATER FARRY 1870 A LIQUIDDOUINATED THE MASS, CHOTHESCAL RESERVOIR
Relcoin A. Chant (Applied Ratheautes Division,
1858), the 1315 bellingen, New Zealand
The effect of theid set ideased and injection
into a two-phase geometrical tenerorist natrix is
considered. The mechanical reservoir is
considered. The mechanical reservoir natrix is
considered. The mechanical prices redding, except
that fragming ensures that injected field
rives fully large reservance from Injection of Insid
causes a pressure change dependent on the fluid
causes a pressure change dependent on the fluid
causes a pressure change dependent on the fluid
causes and rate of injection; nearly always a
researce drep for old fluid injection. In
addition to the pressure disturbance travelling
any free the point of injection, where is a
change in softwation near the injection point
that travels new vertically. Satural perturbations might introduce cold water into a reserbations might introduce cold water into a reser-suir by larged flow. To mabilize the two-phase fluid by chimiting the advance of such the rustom a mability criterion is derived. This is shown to be approprietely assisted by abserved

Meteorology

1205 ALT AMAILE. TIME SERIES SEASON FOR TREND IN TOTAL OF SE

THY SERIES FRANK FOR PFFMD 19 TOTAL CV 20 pFFACERENALS

D S 11 John Periodomicals Dept , Experiorated Nation () 1 John Periodomicals Dept , Experiorated Nation () 1 John Periodomicals Periodomicals () 1 John Periodomicals () 1 Periodomicals () 1 Periodomicals () 1 Periodomicals () 1 Periodomicals () Periodomica

3715 Chemical composition and chemical

J715 Chemical composition and committee interaction and composition and committee and changerinosa. ADMOSPHERIC CARBON DIVIDE AND CHANGES PRESS OF STRAYDS PRESS OF STRAYDS PRESS OF COMMITTEE AND SURFACE TRAYERATURE L. S. Callis (Naki Langley Research Center, Hempton, Virginia 1985) Nursil Research Center, Virginia 1985) Nursil Research Committee and Chicafi Committee Committee (CTVC1). Chicago and chicafi Committee (CTVC1). Chicago and chicafi Committee (CTVC1). dioxide and chiorelinoromethanen (CT2Cl), CTCl; are sesumed. The combined affects on atrato-spharic oxone and temperature are examined with a time-dependent radiative-convective-photochemical model. A steady-state version of the model is used to determine surface temperature affects and to establish asymptotic levels. Results indicate the following: (1) The total ozone rime history is significantly different from that due to the chlorefluoremethanes along (2) A foral ozone minimum occurs in the upper stratouphere about \$5 years from the present with a tobequent ozone increase, then decline; and (3) Strady-state solutions indicate that tropospheric temperature and water waters. and (3) Stray-state obstition indicate (out trapospheric temperature and water waper increased, associated with intreased infrared opacity, cause significant changes in traposphoric arone levels for 2 x CO₂ and 4 x CO₂ with and without the addition of chlorofluoromethaces. (Traposphoric atoms, granuhouse effect, CO₂).

Ceophys. Zen. Lett., Paper 110804

1715 Chemical composition and chemical Interactions
THE DISTRIBUTION OF CAPADN MOMORIDE AND OZONE IN
THE PARE TADFOINGER
W. Seiler (Ker Planck Institute for Chapletry,
Searstrasse 21, 56500 Mains, Federal Papublic of

Germany) J. Fishman
The two-dimensional distributions of GO act O; Germany) J. Fishman
The two-disensional distributions of 60 aci 0;
in the free troposphere during July and August
1974 are discussed. The date confirmation
previous findings that both of these gases are
considerably more abundant in the Horshern Bemisphere, but the degree of the asymmetry is somewhat different from what had been reported
previously, especially for 00. When examinal
with respect to other available date ests, the
conclusion is drawn that a prohumned sensons
rycle salars for 00 in both besimpheres which may
be driven by the likely seasonal cycle of the 001
radical. The date who indicate that for concentrations exhibit significant variability with
height in the Borchern Hesisphere whereas
acuthern hesispheric concentrations are quite
constant with altitude except in cases where
interhenispheric quachange of air may to
accurring. A discussion on the weetlend and
horizontal transport processes interted from
the 60 and 0, measurements is presented. The
observations indicate that the region between
10 N and 40 N is very active photochecically.
It is at these latitudes where the 40 concentrations may be the highest during this time of the
year, resoutling in du area where the 10 destrucper, remuting in an area where the tild defeu-tion rate and the rate of in-mits trajuspheth-azone production may be the greatest. (furbour munnaids, evenc, (respective the checkety) J. Geophys. Res., Green, Paper 1/4/86

3315 Historical Phonorous RATIONS BOWL FOR SPARE IN CONCENTRATION 1, 9, We seen the partners of Physics and Astronomy, University of Machine, Intende, Myo. 820712 and Balton Force communication from small low communitation were made union a formation of demanding the instrument differs from others in that a longular way was 1 to draw air through the for other to their intended as the through the for other true in order as well known and communitation with the process of the control of the process of the control of the process of the control partiable year a two years people (1997-1976). In contrast to provide data, the new profiles are the becoming and they only a could decide in consequentiation above the ion dending marks.
It is delicated that this discrepancy is to be attri-bated to a point; businessed carrielle they rate to rolder Instruments. Swighter Seri, Green, Paper 160/51

1755 Interaction of atmosphero with electro-majorate variable.

EAPTH PARIABLES records:

G. Stageman Hope of Armographic demons.

Calculate Crain Unitarized and Cathorn seasons.

Armographic Crain Unitarized and Cathorn seasons.

The Principle Principle the amount and seasonst and T. V. to relief.

The paper process the amount and sectional averaged watch all maximum railing to the forth derived from the point complete set of matellite observations available in late 1873. The batters are desired from a quadrat 4 derivably man railing being them. annual, global averago emitted inflated flux to 234 W.m. 2, planotary mitels is 0.30 and the ret flux is zero within measurement uncertainty. The annual cycle of that flux is also studied to detail and the conserved placelly averaged not flux displays an annual cycle which is similar in phase and capatitude to the annual cycle interest of the influence of sun earth distance variations on solar radiation input into the atmosphere. A study of the geographical distantion of the annual variability of the not flux rewais that generally greater than 99% of this variability occurs as a result of the send annual cycles which may be forced by the requist variability occurs as a result of the send and annual cycles which may be forced by the requist variability occurs as a result of energy contained in the variance fired year to year is large. Radiative transfer model similations of the observed budget quantities at the "top-of-the-atmosphere" are presented and agree with cheervation at least for the zonally everaged case. Significant differences ratistion budget ratemisticus to these previously settlented. The differences, largely a result of the exclusion of enhanced shoog them the window region (8-14 vm) in earlier hudget that charge in the occase in the thopics than previously estimated. The validity of this result was verified using GATE radiation hudget recognates.

J. Esophys. Res., Green, Papar 100608 flux is zero within measurement unrestainty. The annual cycle of net flux is also studied in

MAJESTIC Llghts_

> The Aurora in Science. History and the Arts

* A definitive work on the Aurora Borealis by Robert Eather

* Reveals new material points out the direction of future research.

* An invaluable work . . .

List price \$49.00 Special member price \$29.40

spanning the areas of planetology, scalar and interplanetary physics, insteorology, geomagnetism, magnetospheric physics and the history of science. clothbound ● fully illustrated ● 106 color plates ● 324 pgs.

Order from: American Geophysical Union 2000 Florida Avenue, N.W. Washington, D.C. 20009

Orders under \$50.00 muit be prepaid Call Toll Free 800-424-2488

Izvestiya Physics of the Solid Earth

CONTENTS

Strakhov V. N. Unsolved plane problems in mathematical theory of gravity and magnetometry Nomirovsky Yu. V., Tyrymov A. A. Effects of periodical relief on in situ stress

distribution

Kuchay V. K., Pevney A. K., Guseva T. V. Near-surface crustal deformations from goodetic measurements over transition zone between Pamir and Tjan-Shan
Blagovesichenskaya E. E. Directivity of P radiotion from a tectonic earthquake

source 45
Balk P. I. On equivalence in a three-dimensional problem of gravitational potential induced by perturbation masses with varying density 54

SCIENTIFIC COMMUNICATIONS Savarensky E. F., Sofronov V. V., Peshkov A. B., Verbova L. F., Peshkova I. V. Scismic stations optimum network minimizing the errors in epicenter location.

Naumenko B. N. Tectonic stress drops due to storm microscisms
Greenfeld M. A., Movelan A. A. Wave fronts refracting and reflecting by bounda-

ries in isotropic non-linear clastic modia
Rozò E. N., Zolotov I. G. Implications of the Earth's magnetic field variations

teristics of rocks

Dvorkin I. L., Filippov A. I., Ladyzhinsky B. Ya. Influence of well-filling materials on geothermal data

CHRONICLE

for shiphorne surveys.

Barsukov O. M. A possible rause of electrical precursors to earthquakes

St. Korotayev S. M. Filtering electromagnetic field of submarine sources

Ul. The effects of diffusion anisotropy on TRM and magnetic characteristics of rocks

Volume 15, Number 8

Particles and Fields—

3720 Interactions between solar wind and magnetic-sphere
observations of Effects From Maintraspheric (US)
MOVEMENT DURING A SOLAR PROFITE VEYNY
R. R. Brown Department of Physics, University of California, Berbeige, CA. 9220 J. R. Bergus,
P. Stauning and R. N. Fares
The Interplaneters respects: field underwent a sitting nouthward turning at the location of the ISE-J apacetrait, with B. (in swiellite coordi-nates) decreasing from 10, to -15r in the Inter-sal from 1940 UT to 1000 UT on August 20, 1979.
Solar wind apead nesturements at the spacetrait indicated that the nouthward turning of the HW should have reached the front of the tognostic-sphere around 1675 UT. At that the the solar proton swent of August 12, 1979 was still in pro-stress. Observations from bail-ton-botne will ground-based footugentation in Greenland in that period, around 1615 tagnette to that time, showed an expansion of the prior cap, the cusp moving tourboard by it less! Adapted in 1stitute in 15 ainutes, starting around 1635 UT. From changes in the energetic photon spectrup at Lillian chilt-tude, it is shoon that the grad at 1stitute in elec-tering for the prior of the perior of the cusp at Sondre Strafejord, Greenland prior to the cusp faction was in the range 6-10 My. (Mayneton-spheric cusp, except), solar proton event.

SYM Regretic tail
ILANS SERT MHITER EXECUTION STRUM STRUM PRERY
ION HEASUREMENTS
H.X. Arkieva, E. Ferplor and F.M. Daly (M.P.I.
for Aerocaute, D.-Mil Katlerburg-Lindau, F.R.G.
Hadium energy ions measured by ISEE-2 are used
to provide information on plasms wheet notion
during expansions following substorms. The
upwards speed of the plasms sheet edge measured
locally is cornouly 50 km/s. It is thought
that waves in the form of field aligned
Cortugations of the sheet boundary may be
responsible for these high speeds in some
cases. The boundary between the lobe and plarua
sheet intermity Fluors is shout 2 qwo raili
thick, or 1000-3000 km at the energies
involved. After the passage of the plasms sheet
boundary, particle fluors drifting down towards
the neutral sheet are often encountered. This
is interpretted as an EAS drift, and implica
electric fields of about 1 m/m, which could
imply high cross-tail potentials. At the outer
boundary of the sheet, the streaming ion layer
is found to have a pasked spectrum which softens
as the plasms sheet is approached. The rising
plasms sheet to approached. The rising
plasms sheet to behaviour of the streaming ion
layer are consistent with the tailward motion of
a source region together with a cross tail
electric field. A source location 50-100 Rg
down-tail was deduced, (Plasms sheet expansion)
J. Geophys. Ass., Blus, Espan 186601

SIM Magnetic tell

paratied Study on acceleration and Propagation
of Emercetic Propose and Electrons in IME
Macketotall Doning Substorm activity
E. Kirsch (Mar-Planck leastinate for Astronomy
1841 Katlenburg-Lindau 1 West Generally
3. M. Kringis (Applied Physics Laboratory/The
Johns Rophins University Lears), Maryland 208(9)
E. I. Sarris and E. P. Lepping
High time resolution magneteents of energetic
particles (E. > 0.27 May, E. > 0.27 May) shidsing
the Care magnetosates both about the JMP-8
satellite in the distant magnetotall (Ngg = -26,
Ygg = +18, Ngg = -16, Rg) are presented on
November 28, 1971, when deven of the highest
intensity particle bursts were detected in
Marchine 2 wears of observations by the DMP-7
servatory 2 wears of observations by the DMP-7
servatory 2 wears of observations by the DMP-7

Veg. +18. Zeg. - vi. 6 R.) are presented of the highest intensity particle bursts were detected in marily - 9 years of observations by the Diff-Y and Diff-8 spacecraft. The Attindex and magnetic grass of auroral stations indicate that this day was noderably disturbed magnetically. The observation for the secretary disturbed magnetically. The observation particle bursts were associated with rayle changes in the magnetic field, including both positive and negative averations in the 3 component. One of the magnetic field, including both positive and negative averations in the 3 component. One of the particle bursts was ancompanied by a questperiodic nesthermouth fluctuation of the most intense burst was associated with a rapid change (- 28 y in - 4 bec.) in the 3, component; during this borst the intensity of - 1 May protons increased ~ 20 one later than for - 0.1 May protons and electrons varied from - 1 to - 6. The appearance of a-particles is to 1. May part of a protons and electrons varied from - 1 to - 6. The appearance of a-particles at > 1.4 May and the absence of 2.20 May protons anguages the presence of of the most intense bursts as well as derived only particles up to - 1 May Protons augusts the presence of 2.20 May protons anguages the presence of of the most intense bursts as well as derived only particles up to - 10 for human the absence of field-nigmed slectric fields. Some of the bartle field leaving up to - 80 one have burst possible of particles and electrons parallal to the sail field leaving up to - 80 one have burst fields and protons and electrons parallal to the bartle revealed that protons and electrons relatively of protons and electrons withfating large tallward and tallward discussed protons and selectrons respectively).

The intense bertie bounds spatially segmented to be associated with both cloaded and open field leaves to be associated with both cloaded and open field into a described as protons field as protons and electrons of the observations are discussed in the components welcome

dynamical magnetospheric processes. 1. Georgys. Rus., Mins, Paper [A0693

9736 Magnetic tall ILASSA SHEET MITTING DESCRIPT THEM MITTING PARKEY

Magnetosphere

With Particle and across a Children by the CAMSE Property of the ATMOSPHER DESIGNATION OF PROMISE THE STATE OF THE ATMOSPHER DESIGNATION OF STATE OF THE ATMOSPHER DESIGNATION WAVELED THE EACH OF THE ATMOSPHER O

J. Geophys. Pers., wreem, Paper LOTEN

3770 Particles and Acrusols

AFROCOL FORMATION, TRANSFORMATION AND EFFECTS IN

UNIVER'S EMISSIONS SELVE.

C. C. Van Valle (Office of Meather Pesearch and

Medification, EPL, MARA, Boulder, Co 80303)

R. F. Reschel and D. C. Wellran

Aerosols and trace gases over the Denver Letro
politan area and in one case to 175 km domaind

were resoured with an instrumented afrocafe.

Typical background concentrations measured above

the polluted layer were: light scattering co
afficiant (bacas), 0.2 x 10 ° ° 1, 10 tan 1, 3 n, 10

parts per billion (ppb), 30, ° 5 ppb; M0. « 5

ppb; M0. 5 ppb. Below the inversion and near

the city center (main existions source) typical

measured values were as follows: b_cast 0.5
1.5 * 10 ° ° 1' (m, 10 ° cm 2') 0; 10 ° ppb; M0. « 5

the pluma aged, the CH concentration was found to

decrease to one-third or one-fourth of the ini
tial value, but beggt increased, in one instance

to 4 x 10 ° ° 1' (m, 10 ° cm 2') 0; 10 ° ppb; M0.

To of the value predicted by the 0, and N0

concentrations and solar irradiance, romoval of

M0. by dissolution in Hould water is indicated.

For refractive inities assumed to be realistic

for dry urban aerosols, the absorption-to-back
scatter ratio decreased with increasing age of

the climal. Therefore, freshly formed emission

plums had the potential; tooling probably occurred

were maining to "Later In No. 10 ° pp.

T. Lenghys, Pers., Green, Paper Irusol

the tablish new . Parm, twellight, seressi). J. Campbys. Page. Blue, Paper 149137

1/1/2 Particles and arranols

[Outh LANGENTH MEMICONITER MEASUREMENTS AT

SOUTH POLE

Parry A. B. Indiane (MOLA-API-COCC., 125 Broadway,
Rudder, Colorado 830011 and John C. Bertaniah

A four waselength rephilemeter was installed
at 5-th Pole station in January 1979 an order
to measure the solumetric aerusal stationing co
fill fout Juring the austral winter of 1919. The
working mean around light sectioning at 500 nm

waselength for May was 1 21a10 m. the lowest
monthly mean value ever recurded an any CMCC ata
tion. This implies a total aerusal mass loading
of 10 ng m. 3, in agreement with aerusal mass loading
of 10 ng m. 3, in agreement with aerusal defendance.

The investments at State Pole station. Colfensation

policy connections in 1979 sample between rules contentrations in 1979 same teteren monthly means of 185 cm 3 in Jebruary and 10 cm 3 in July. Senyhya, Wem. Lett., Paper HEQ723

1790 Instruments and Tuchniques

PEPEATABILITY AND MEASUREMENT UNCRETAINTY OF THE

UNITED STATES METEOROLOGICAL ROCKITSONDE

F. J. Schandlin (Directorate of Applied Science,
MESA Mailops Flight Center, Mailops Island, VA

2133/USA)

Recote temperature measurements from satellites
are turrently validated using rocketsonde and
radiosonde data and other reliable "ground truth"
data. The raliability of the validation is
directly dependent upon how well measurements
from all of the techniques represent the atmosphere Past experience indicates that remote
and in sity ream values usually agree within a
fow dogrous, but that the individual observations
may be pourly correlated. It has been suggested
that this ray be due to atmospheric variability
which is observed by the nocketsonde and radiosonde technique but unresolved by the satellite.
This observed wariability, especially when
reasurements are obtained close in time and
space, Is of particular concern since this raises
the question whether the variability is due to
natural atmospheric change or arises from instrucented instabilities. It is shown that the US
rocketsonde, the Super Loxi Datasonde, provides
reliable temperature measurements to about 1°C.
A tample of resurrents obtained close together
in the is analyzed to provide this estimate, it
is Leportant that the Middle Atmosphere Program
(MAP) Late advantage of the rocketsonde's measurrent capability not only to validata remote
seasurements but in chaining detailed measurecents of localized phenomen in the middle atmosphere. (Atmospheric Temperature, Stratosphere,
Precision, Instrumentation)
J. Geophym. Ros., Green, Paper 16056

3799 Ceneral of Discrilaneous Analysis of Linear and Hamiltnear Inversion of Offi-cal Data for a hickometerological Temperature Pro-

izvestiya Atmospheric and Oceanic Physics Volume 16, Number 4

CONTENTS

Grechko G. M., Gurvich A. S., Romanenko Yu. V. Structure of Stratospheric Density Inhomogeneities after Observations from Orbital Station «Salyui-6» Gurvich A. S. The Influence of Time Evolution of Turbulent Inhomogeneities on the Frequency Spectra

Blank A. D. Perturbations of the Upper Atmosphere Caused by Flow over a Mountain Ridge Vakalyuk Yu. V. On Estimate of Available Potential Energy in Pressure Coordinates Garger E. K., Naydenov A. V., Uvarov D. B. On the Cross-Section Diffusion in the Almospheric Surface Layer

Kolosov V. V., Kuzikovsky A. V. Variation of Intensity of Temperature Turbulent

Bogorodsky V. V., Kozlov A. I., Vagapov R. Ch. The Polarization of Thermal Neizvestny A. I. Kobzunenko A. G. Experimental Determination of the Collection Fridman V. E. Comparison of Empirical and Theoretical Laws for Explosive
Acoustic Waves in the Ocean

Volt S. S., Lebedov A. N., Sebekin B. I. On a Certain Model of the Tsunami Waves

Generation by the Finite Rottom Displacement Kozlov V. F. Formation of the Rossby Wave Induced by Disturbances in the Non-Stationary Barotropic Oceanic Flow

Gledzer E. B., Makarov A. L., Ponomarov V. M. On the Stability of Elliptical
Relation of a Fluid in the Presence of Coriolis Force
Bubnov B. M. Experimental Study of Stability of Fluid Motion Inside Elliptical
Cylinder in the Presence of Coriolis Force
Chernous ka Yu. L. Experimental Studies of Two-Dimensional Flows with Horizontal Shear in a Relating System
Skhirtladze G. L., Yurchak B. S. Measurement of Parameters of Atmospheric
Diffusion in Wind Shear Regions by Radar Method
Shapire G. I. Effect of Fluctuations in a Turbulent Entralament Layer on Heat
and Mass Transfer in the Upper Thermocline
433 Phhalagov Yu. A., Uzhegov Y. N. The Effect of Rain Showers on Optical Proporties of Marine Coasial Hazes

PRHSOXALIA

J. Geophym. Rew., Green, Paper 100566

Jigo Instruments and techniques (meteorology)
ON THE SERSIFIVITY OF NUMERICAL MEATHER PREDICTION
TO SEMPIFELY SERSED MERLINE SURFACE WIND
DATA: A SIMULATION STUDY
M. Cane (54-1720, Mussachusetts Institute of
Inschnology, Carbridge, MA 02139), V.J. Cardons,
M. Haller and I. Halbersters
A series of observing system stemation experisents has been performed to assess the potential
impact of marine surface wind data on numerical
weather prediction. Care was taken to duplicate
the spatial coverage and error characteristics of
conventional surface, radiosonde, ship and dircraft reports. Those observations, sustably
degraded to account for instrument and sampling
arrors, were used in a conventional analysisforecast cycle. A series of five 72-h forecasts
were then cude using the analyzed fields as initial conditions. The forecast error growth was
found to be similar to that in operational numerteal forecasts.

Further experients simulated the time-continrows assimilation of remately sonsed curine surface wind or temperature sounding data in addition to the conventional data. The wind data
were fabricated directly for model grid points
intercepted by a Sessat-1 scattoromer (SASS)
such and were placed in the lowest active lovel
(945 rb) of the rodel. The temperature sounding
experiment assimilation error-free with those of the
control forecasts.

You error-free winds were assimilated and the importory the simulated satellite data as assessed by
congaring these forecast errors with those of the
control forecasts.

You error-free winds were assimilation using a
localized successive correction exhed (SCH) the
import of the rodel regions proved to be
sobstantial, especially in lower troposhoric
control forecasts.

You error-free winds were assimilation on ferorfree sounder data face as valuable as tenferiture soundings for ourarical weather prediction.

The offects of neutral passimilation on the
solutions of the control of the control of the control of the control

FILE

William H. Math (Department of Meteorology, Florida

William H. Math (Department of Meteorology, Florida

State University, Tallahesses, FL 12006)

The practical inversion of optical data for a

micrameteorological temperature profile requires a

monlinear inversion of a system of polynomial equa
tions. A mathod of monlinear least squares can

produce a physically acceptable solution of this

monlinear inversion problem. Because this method,

which is demonstrated with the inversion of simu
lated optical data, does not produce an unique mo
lution, the images of targets are calculated and

used to reamine the molution. A solution of the

Am. Kineralogist, 66, 5-6

OHRUNIOLE

Golitsyn G. S. Session of the Division of Oceanology, Atmospheric Physics and Geography of Academy of Sciences of USSR together with the Interdepartment Scientific Council of Academy of Sciencies and State Committee on Hydrometerology and Control of Environment on the Problem The Weather Forecasts (Novosibirsk, 1—2 November, 1979)

Genin V. N. Zuev V. E., Kabanov M. V. V All-Union Symposium on Laser Light Propagation in the Atmosphero
Ivanovsky A. I., Koshel'kov Yu. P. Studies of Stratospheric and Mesospheric Physics Reported at XXII COSPAR Session (Bangalor, India)

Rozenberg G. V. Soviet-American Forest Aerosol Experiment in Abasiumani 442

nonlinear inversion problem is physically acceptable when these images agree with minutated images to within expected errors of measurement. The nonlinear inversion of optical data contaminated with errors is shown not to be a difficult problem, because the method of monlinear least squares implemented to find a solution is efficient for the particular priyocolal equations that must be inverted. (Fonlinear least squares, Miragaes).

J. Geophys. Res., Green, Paper 100689

1799 General or miscallencous
SCHE ASPECTS OF THE COUPLING RETWEEN RADIATION,
CREMISTRY AND DYNAMICS IN THE STRAYOSPHERE
Dennis L. Eartmann (Department of Atmospheric
Sciences, University of Veshington, Seattle 98195)
A number of machanisms involving interaction
between radiation, photochemistry and dynamics
which may affect the thermal compositional or
dynamical structure of the atratosphere are discussed. The affect of coupling between radiative
transfer, photochemistry, and advection of onome
by stratespharic winds on the affective releastion rate of temperature perturbations is illustrated through the use of four examples. It is
shown, for the vartical atructure typical of
planatary waves, oxoma floctuations act to hesten
the relaxation of temperature perturbations in
the upper stratosphere and to slow the relaxation in the lower half of the stratosphere,
Mant the coupling between chemical sources and
sinks of occurs and advaction of six by motions
is discussed. A simple Lagrangian model is esployed and related to resolts from Eulerian model
studies. Emphasis is placed upon the large eddy
transports produced at the transition level between dynamical and photochemical control of
excess, and also upon the mean excess increases
which eddies can produce in regions where there
are sharp gradients in both the equilibrium onone
mixing ratio and the releasation time scale for
excess perturbations.

sixing ratio and the releastion time scale for ozone parturbations. Finally, the apacial variations of the effective releastion rate of temperature parturbations are shown to be potentially important in determining the mean structure of the stratosphere during the winter season. These spatial variations in the releastion of temperature perturbations in the releastion of temperature perturbations result from oxone variations produced both by chamistry and motions. In particular, a rapid increase in the effective desping rate of planetary waves between the middle and upper stratosphere leads to a repid increase with height of eddy heat transports produced by the coupling between radiation and dynamics. This in term can produce a significant modification of the sonal mean structure of the upper stratosphere, J. Geophys. Rea., Green, Paper 100221

Mineralogy, Petrology. and Crystal Chemistry

4210 Crystel chemistry THE CRYSTAL CHEMISTRY OF THE URANYL

4210 Crystal chemistry
THE CAYSTAL CHEMISTRY OF THE URANYL
SILICATE MINERALS
F. V. Stohl (Sandia National Laboratories, Org. 473). Albuquerque, NM 87185]
D. K. Smith
The uranyl silicate minerals have
been divided into three groups on the
basis of their uranium to silicon ratios.
The lil group includes uranophane, betauranophane, boltwoodite, sodium boltwoodite, kasolite, sklodowskite, and ouprosilodowskite. A structure refinement of
uranophene, a structure determination of
boltwoodite, and previously reported
atructure determinations of most of
these minerals indicate that they are
composed of uranyl silicate chains made
of edge-shared uranium pentagonal bippramidal groups and silicate tetrahedra.
These chains have the composition
([UQ][SiO4]]-A and are crosslinked by
a bridging oxygen atom to form a uranyl
silicate sheet. These sheets are crossbonded by the additional cations in the
structure. The uranyl minerals with a
uranium to silicon ratio of 1:1 include
waskite and haiweile. A partial
structure analysis of weeksite suggests
that the structure type for this group
consists of uranyl silicate chains,
similar to those found in the 1:1 group,
that are crosslinked by the additional
silicate tetrahedra in the structure.
The uranyl mineral group with a uranium
to silicon ratio of 2:1 contains only
the mineral soddyte. This structure is
composed of uranyl silicate chains that
are crossbonded by shering a common
silicon to give a three-dimensional
framework structure. A new triclinic
uranyl silicate mineral was discovered
during this study, slithough there is not
anough sample to describe it adequately.
The locations of the uranium atoms in
this structure indicate that it may not
be composed of uranyl silicate chains
such as those found in all the other
uranyl silicate minerals. (Uranyl
silicates, boltwoodite, weeksite,

4210 Crystal chemistry
THE "10A PHASE" IN THE SYSTEM MgC-SiO2-H20
J.F. Bauer (Johns-Kanville Research and Development Contert, P.O. Box 5108, Denver, Colorado
SO2171 C.B. Eclar

Social C.B. Eclar

The 10A phase is a unique pressure-dependent
hydrous phylicalicate in the system 180-3102-180
which is atable at pressures between 12 and 55 hb
and temperatures up to 535°C. Although it was
previously observatived as a 2-outshedral menher of the mice family, reexamination of this
tural madel represented by the formula
(1890-1818-1828-1818-1922(OH2). The results of
I-ray powder diffraction analysis, thereal analyals, and experiments in which the stoichiometry
of oxide starting mixtures was carefully controiled indicate that the structure of the 101 trolled indicate that the structure of the log place is that of a fully trioutahedral 21 phyllosiblicate; it is similar to that of take, but contained additional chemically-bund "wager" in 12-coordinated sites (1200)2 lagg [35] [3020(69)]. The results of infrared appearance(), however, indicate that this "water" is best represented as condime ions [374] formed by interaction of the 12-coordinated interlayer HyD moderates with certain cetabedral-layer hydroxyl groups according to the relation:

850 • CM • 830+ + 05ago off - 2 Jo - 2 Co - 2 Jo - 2 Co - 2 Jo - 2 Co -American Mineratogist, 66, 5-6

4720 Descriptive mineralogy
MYDROIHERMAL ALTERITION IN RESEARCH ORILL HOLE
Y-2. CORK GEYER BASIM, YELLOWSTOE MATIDMAL
X.E. Bayyar And M. M. Besson (U.S. Seological
Survey, 3/5 Myddisfield Rd: Monic Park;
California 94025
Y-2. a U.S. Seological Survey research dismonddrill hole in Lower Seyser Basim, Yallowstone
Matiboal Park, west deliled to a depth of 157,4
malars. The hole penetrated statemental
illegous winder and fravertine to load at
illegous winder and fravertine to load at
ctal sediments of the Principle discinsion joint

layared with pumiceous tuff from 10.2 to 31.7 a, and rhybitic layas of the Elephant Each flow of the Central Plateau Member and the Mailard Lake Member of the Pleistocene Plateau Rhybite from 31.7 to 157.4 m. Nydrothermal alteration is pervative in most of the nearly continuous drill core. Rhybitic glass has been extensively altered to clay and zeolite minerals (intermediate neulandite, clinoptilolite, mordenite, monteonilolite, and illite) in addition to quartz and adulation. Almoerous veins, vugs, and fractures in the core contain these and other minerals: silica minerals (opal, 6-cristobalite, and chalcedony), zoolites (analcine, wairabite, and chalcedony), zoolites (analcine, wairabite, and chiorite), oxides (hematite, gouthite, manganite, cryptumelane, pyrolusite, and groutite, and sulfides (pyrhotite and pyrite) along with minor aggirine, fluorite, truscottite, and portlandite (7).

Interbedded travertine and silicaous sinter in the upper part of the drill core indicate that two distinct types of thermal water are responsible for precipitation of the surficial deposits and further that the water regime has alternated between the two thermal waters more than once since the end of the Pinedele Glaciation (-10,000 years 8.P.). Alternation of zones of Calcium-rich and sodium— and potassium-rich hydrothermal interals, carbonales, sulfides, oxides, adularia)

Am. Mineralogist, 66, 5-6

4230 Experimental mineralogy and petrology PARTITIONING OF REE BETWEEN MINERALS AND COEXIST-ING MELTS DURING PARTIAL MELTING OF A GARNEY LHERZOLITE

LMERZOLITE Wendy J. Harrison (SN6-NASA Johnson Space Center, Houston, TX 7705B) Partition coefficients $(\underline{D}_1^{\bullet}\underline{D}_2^{\bullet}) = \underline{C}_1^{\bullet}\underline{C}_2^{\bullet}\underline{D}_1^{\bullet}$, where G_d is the concentration of element \underline{I} in phases \underline{a} G is the concentration of element I in phases a and b) for Ce, Sw, and Im between garnet, climaryroxens, orthopyroxens, olivine, and belt have been determined at 35 bbar for 2.3, 8, 20, and 37.75 Melting of a garnet therapilite nodule with chondritic REE abundances. Partition coefficients increase as the degree of partial melting increases. From 2.3 to 85 melting, this increase is largely a consequence of non-Henry's law behavior of REE in minerals. At melt percentages 29%, changing temperature and melt composition, as well as non-Henry's law behavior, also in-fluence the values of REE partition coefficients. The total increase in December 100.00 melting to the sale of REE partition coefficients.

The total increase or Ret partytion coefficients. The total increase in Dage Trystal/melt from 2 to 38% melt may be up to 100% for some minerals and REE, and the assumption made in patrogenetic modeling of constant partition coefficients is therefore questioned.

Experimentally determined REE abundances in the 2.3 and 8% melts can be adequately modeled with an equilibrium partial melting model and a melting reaction, determined by Mysen (1973), in the system Ca0-Mgo-Algo-SiO: garnet + 0.67 dioside + 0.14 enstatitag0.22 forsterite + 1.61 liquid.

REE abundances cannot be calculated at higher percentages of melting because the melting reaction is not known.

The LREE anrichment in the 2.3% melt is 22 times chandritic abundance, and this melt has chondrite-normelized Ce/Tm = 4.18. The generation of REE abundances typical of most alkali basalts (Ce enrichment 40-200 and Ce/Tm 2-16) is not possible awan by low percentages of partial melting of a garnet Therzolite unless the material has been enriched in LREE relative to chondrites. chondrites. Am. Hineralogist, 66, 3-4

4239 Experimental mineral by and petrology PHASE RPLATIONS OF TOMOSTATE MINERALS PRICE PYRRO-MYERPAL COMPITIONS
L. C. Hau Kneward Bureau of Minus-Caelogy and Dept. of Geological Sciences, Mackey Rehool of Minus, University of Royale, Runn, By 89557.
The binaty whenc relations of several naturally occurring tumpscate minerals, of the general form MASHOA, were inventigated invirothermally at fluid pressure of 1.0 khar and temperatures of And'C to 900° c. A complete solid mointion, with tetraporal systems, between schoolite (MASHOA) and stolated fly invasiance with tetraporal teymostry, between schoolite (MASHOA) and stolated (EMBOA) forms a complete solid mointion of Monoclinic avenuetry with both ferbrite (FabOa) and huebmarite (MABOA) forms a complete solid multion of Monoclinic avenuetry with temposition. Moid solutions yare linearly with composition. Moid solution is very listed hotween monoclinic and certagonal tumpscates. Loss than 5 mil. Talagibility of one in the other is observed at temperatures up to 900°C.

to quark. It all the solld notation spons thems tempatate minorals is affected atrought by both the availability and onvironment of the atructure sites for specific divalent cations. Even where atructural limitations permit extensive substitution, physicochemical characteristics of elevations such as 7m and Ph may still restrict the occurrance of said solution in nature. (Tungstate minorals, hydrothermal phase equilibris, said solutions). eolutions), Am. Mineralogist, 66, 3-4

4230 Experimental mineralogy and patrology HIGH-PRESSURE STABILITY AND TREMNOTHANG PROPERTIES OF CoSiO, Stavan R. Bohlen and A. L. Boattcher (Inmitute of Baophysics and Planetary Physics and Department of Earth and Space Sciences, University of California, Los Angeles, California 70024).

We determined the stability of CoSiO, relative to Co,810,4810, with reversed experiments in a piston-cylinder apparetus. Our data at 1023, 1173, 1323, and 1473 K indicate insuchility of CoSiO, below 17.2, 18.0, 19.1, and 20.4 Kbars-Adgss and Alfies (from oxides) calculated from our data between 900 and 1500 K are -12,540.2 bi and -8,050.2 bi, respectively. The dP/sft slopes of phase transformations in Fe-bearing systems in planetary interiors that are inferred from Committees, high-pressure phases, experimental aineralogy.) Geophys, Res, Lett., Paper 11.0507

4230 Experimental mineralogy and petrology POTENTIAL FOR GEOCHEMICAL EXPERIMENTS IN LARGE SCALSTESTS (including ranges of atreases, pore fluid pressures and compositions, and temperatures) R. J. Vidale (Los Alamos Nations) Laboratory, Group CMC-7. MS 514, Los Alamos, New Maxico 87545, USA)
Geochemical problems that would bepurit from large scale experiments include: 1) the determination of the physical properties of the many common rocks that are chemically homogeneous on the scale of 5-100 cm but not on a scale of 15 cm, 2) the study of the influence of rock textures and compositions and of the chemistry of the pore solution on atress, corresion cracking, and 3) the study of chemical transport within gradients in temperature, chamical transport within gradients in temperature, chamical potentials and stress. The ultimate goal of a few well-chosen large scale studies should be the development of predictive models.

Geophys. Res. Lett., Paper 110732

4230 Maneral cocurrences and deposits
THE CRYSTAL STRUCTURE OF A MEXICAN ANTHITE
J. Braves Swinnes (Materials Science Laboratories, Department of Chumical Imgineering,
The University of Texas at Austin, Austin,
Texas, 78712 Bugo Steinfink, L.E. RendonMassMiron and S. Ruciso de la Vega
A new decurrence of armite and its chasical
composition is reported. A three-dimensional
X-ray diffraction structure smalysis was
astried our using 3,124 observed structure
smallings. The refinement converged to
any 50.05, ME - 0.050. The Mag-7; bard, and
"Act ions occupy the distorted, "Fe" ociahedral
site; the board distances and angles are sessitially conchenged from those reported by
Tekkudah et al. (1974). (Grystal structure,
Manich Stimles).

And Miteriologist, 56, 3-4.

a250 Faragensis, patrography, and petrogensis CZESISTRY OF ROCK-FORMING MINERALS DY TRE CREMINGS-PARLECERS EATHCLITH IN SOUTHERSTERN LIAVIN AND LOTHCATIONS FOR MAGNA CHASTS |
LAVIN AND LOTHCAT |
Madna Fark, California, 94823) Ehunac Ishihara |
Radio Fark, California, 94823) Ehunac Ishihara |
Madna Fark, California, 94823) Ehunac Ishihara |
Madna Lavin Andrews |

#250 Paragenesis, petrography, and petrogenesis CALEDONIAN PLUTONISM IN SRITAIN:
A SUMMARY
G.C. Brawn (Department of Earth Sciences, The Open University, Million Keynes, MK7 6AA, UK) J. Cassidy, C.A. Locke, J.A. Plant and P.R. Simpson
The Caledonian granites of Britain are a wide-tranging wite of pre- and post-tectonic honalite-granodiarite-granite inhusions which were emplosed in the time interval 650-380 Ma ago. The volume of magmatic product and the frequency of intrusions increased with time or closure of the lapetus acean occurred across the Caledonide belt in the British Isles. Early pre-tectonic and post-tectonic intrusions (older than about 410 Ma) are distinguished from a later (post-410 Ma) group uning geophysical (gravity, aeromagnetic and heat production) as distinguished from a later (post-410 Ma) group using geophysical (gravity, aeromagnetic and heat production) and geochemical data. The evidence is interpreted in lens of a tread with time from relatively local thermal and aust-dominated melting events to a final widespread sailing event at deeper levels. The latter event produced abundant intrusions with characteristics that resemble the calc-alkaline batholiths of modern destructive margins. Finally, we propose that crustal growth during the Caledonian paried took place by northwards accretion of the European continental forel and and by vertical ecaretien of the continental crust on both margins by underplating and by later Intrusive magnetism. depitating and by later intrusive magmat Geophys. Fes., Red, Paper 150704

\$260 Paragenesis, petrography, and petrogenesis GEOTHERMOMETRY AND KINETICS IN A TWO-SPINEL PERIDOTITE NODULE, COLORADO PLATEAU GEOTHERMOMETRY AND KINETICS IN ATWO-SPRIEL PERIDOTITE NODULE, COLORADO PLATEAU

Buglas Smith (Department of Geological Sciences, Cuversity of Texas at Austin, Austin, Texas 787[2] and Michael F. Roden.

Compositions and Zoning of minerals in a two-speel peridotite from minorte in the Nevalo volcanic lited on the Colorado Plateau provide unusual opportunities to compare geothermometers at low manife temperature and to attudy equilibration rates. The tenolith contains pleonaste (Mg. 55 Fe. 30 1.65 Fe. 10 Cr. 28 °) and magnetite (Mg. 16 °. 28 Mn. 0.1 1.8 Fe. 1.32 Cr. 32 °1.06 °a) related by gravie exolution, together with olivine (Po35), orthoproaten (3.5% A163), and clinopyrozeno. Both to-spacel equilibria and several olivine-pleonaste geothermomaters indicate equilibration near or below 70°C, confirming the general accuracy and continued equilibration of these geothermometers at low temperatures. Calculated olivine-magnetite temperatures are near 300°C.

Olivins is zoned in Ca, Pe, and Mg within 50 micro-reters of spinel by exchange with local grain bordary melts. Gradients at pleonaste-magnetite tracets were caused by multicomponent diffusion site heating by impette effects include dight ophil diffusion of Cr. Effective binary diffusion coefficients mear 100°C, estimated by comparison such gradients in oliving, are near 10° /sec for A in pleonaster as average Mg value is in the same range.

The time interval between plucking of the inclusion and muestic soliditication is calculated as about 60 form, consument with ascent times calculated ascaning Newtonian viscosity for the minester magnas. The temperatures calculated for olivine-lynel equilibria confirm the low temperatures in the open manife of the Colorado Plateau interred from Lynel geothermometry, minette).

5. Hineralogist, 66, 3-4

to. Hineralogist, 66, 3-4

olio Paragamela, patrography, and patrogamezia FITACCHESIS OF ECLOGITES AND PERIODITES FROM THE VESTERN AND LIGURIAN ALPS V. G. Irus: [Dept. of Earth and Space Sciences, Chivality of California, Los Angeles, CA 90024) alcohomous paridolites and sclogices of the Matier and Ligurian Alps have been investigated in terms of their mineral susceblages, major element place to expositions, and bulk-rock REC anjor element chemistries. Except for the Mrastiferous ultramafic loss exposed at Alpeard, all studied periodicties sere apinel lheribites. The paridolites whow light REC deplations due to low-tamperature hydrous alteration, to the hypothesized incipient fusion of a now crapterally obliterated gamest-bearing procellite already fractionated relative to primordial REE decisions. Enlogite rocks are tholalitic in their anjor element affinition, but show apparate ususmantic effects of from, citanium and EZ loss, and sikali antichasat during pervass act objectious late-stage recrogramsion to Branchic facing assemblages; however this processes in the presence of a high-rich laucogabiro. Exploying various specific politics for the last reception of oltrametic and mafic units have been topolism.

SOUTH ALPINE PLATS 900°C 925°C 925°C 1000°C 1100°C *10 kb *15 kb *15 kb \$12 kb *15 kb \$12 kb v. Ligoria s. Ligoria Lilogicas (nons) Peridotites Aire Arand Zernata V. Liguria Eclosites Aire Arand Zernata V. Liguria Permana MORTH ALPINE PLATE 950°C <600°C <600°C 900°C (40 kb) 525°C 210 kb 435°C 210 kb

Lituria 347°C 210 kb

bringrade smemblages are incerpreted in
ferm of a marrly adiabatic secont towards
freent crustal lawsis for all investigated rock
lyes, in watern Liguria and the vicialty of
clast this Pri trajectory may reflect buoyant
satural educated crustal sections + serpantion towards the surface of southward and
tired peridotic underplunings during late
tal suplement of large maneau of relatively
depressing of these maneau of relatively
depressing sections of the south Lipine plate
tion section of the south Lipine plate
tion section of the south Lipine plate
tion section of the south Lipine plate
portation of place maneau of centenin inhriceportation of place water trains
plate meritaged and wastward during converdess. Mineralogist, 56, 3-5 inca. A. Hineralogist, 66, 9-6

Park, California 94025, U.S.A.) S. D. Ghent, and J. S. O'Esti Park, Californis 94025, U.S.A.) S. D. Ghent, and J. B. O'Mail
Gernet-two-mice granites of Jurasic (150 ± 3
m.y.) and Cretaneous (84 ± 1.3 m.y.) ages
intrude amphibolite facies metasedimentary
rooks of Frecambrian age and lover Falectoic
addimentary rooks in the northern park of the land season of the season o

4270 Properties of minerals
VISCOSITIES IN THE SYSTEM ALBITE-ANDERNITE
D. Crammer and D. R. Unimann (Massachusetts
Institute of Technology, Cambridge, M. 02139
Viscosities of several compositions in the
albite-emorthite system (AbgoAnzo, AbgoAnzo and
AbgoAng) were measured over a wide range of
temperature (300-1000°C). The log n warens I/T
relations for all compositions show continuous
curvature. In the high temperature region
(T-1200°C), the viscosity (acreases monotonically with increasing Ab content; but the change
of viscosity with temperature increases with
increasing An concentration. Hence the
viscosity-temperature relations show a region of
cross-over; and at sufficiently low temperatures
(12,750°C), the viscosity increases with
increasing An concent. The productions of
models based on free-volume theory and the
mead-capitical models of Bottings and Weill
and Shew are in close accord with the data
within + 0.2 in login in nordy all cames).
(Viscosity, Albite, Amorthite),
J. Geophys. Res., Red. Paper 180617

4270 Properties of minerals NATURAL ARMEALING OF PLEOCHPOIC NAIGES IN SIGTIFE SAMPLES FROM DEEP DRILL HOLES, FENTON HILL, NEW

marrow depth-temperature range for annualling of pleochroic beloes in biotice. Accessing of the pleochroic baloas in blotice. Annealing of the haloas is first observed in emplas from a dopth of 1850 m (134°C) present temporature) and is complete in semples from a dopth of 2120 m (151°C). The observed temperature of annealing of the haloes is in good agreement with earlier observations of flesion track annealing in apartite from the same core semples. (Malo annealing, radioactivity).

Geophys. Fes. Lett., Paper 110591

4290 Instruments and tachniques
100 MICSUPRORE TECHNIQUES AND ANALYSES
1. M. Steels, B. L. Hervig, T. D. Sutcheon and
J. V. Smith (Department of Geophysical Sciences,
University of Chicago, Chicago, IL 60637).
Experimental conditions for major, minor and
processing of the conditions for major, minor and

Exparimental conditions for major, minor and trace alement analysis of clivins and low-Capyroxens are described and analytical accuracy tested using suites of testural samples spenning a vide range of Ng/Fa.

Special attention was given to gample cleanlines to avoid contamination, instrumental vacuum to alianusts hydrides in the secondary ion spectrum, and sample preparation or give good precision in measured intesfers a Expanishly bothersone ware molecular interferences in the secondary ion spectrum which were separated from snealytical peaks using mass resolution (M/AM) ower 3000. Careful analysis of the secondary ion spectrum allowed choice of either high or low mass resolution depending on the presence of interferences. Lithium (0,002), 7 (17), Ma (0,01), Ma, Ad (0,1), St. 7 (3), E (0,02), Ma (0,1), Na, and Co (1) were analysed at low resolution with detection limits (ppm) in parentheses. Elements requiring high resolution include Ca (1), Sc (1), Ti (1), 7 (1), cr (1) and Mi (5).

parentheses. Elements and the parentheses of the secondary-ion intensities for Mg and SI do not correlate linearly with composition whereas, not correlate linearly with composition whereas, has been a secondary ion of the Pa is nearly linear. The simple relation of the Pa is nearly linear. The simple relation of the Pa is nearly linear. The subject element ion Rg/Og+ Pa' next to the meabured secondary ion ratio Mg+/Sit + Pa') subject and Mg+/Sit are not simply related to stonic ration in the terget. To test accuracy of sinte lasent descripation, are function of major element variation, secondary-ion intensities were compared with necessary-ion intensities were compared with compositions based on electron probe measurements. Some alements (AI, Cr. Tr. No.) give a lidear relationship with no obvious matrix affect, but Ni, and possibly Gs and Co, dafinitely depend on the necessary resent by reference to known elements. It was relationship in the composition deposites and the control product is required to achieve this. No. P. V and Sc for which few real tools standards exists.

exist. Am. Himeralogist, 66, 5-6

higher at 480° and 570°C. The compositions of the granites plot near minima melving compositions in the water-alturated quarta-albits-orthoglase system. Comparision of muscovite plus quarts stability, the water-saturated granite solidus, and experimental garmet-melt equilibria suggest pressures of orystallization no lower than about 3.5 kber. This pressure is compatible with that estimated from garmet-plagicolase-sillimanite-quarts equilibria for the intruded metamedimentary rooks. (Geochronology, isotopes, granite).

J. Gmophys. Res., Red. Paper 180814

J. Gasphys, Ras., Rad, Paper 186834

PARTICIS FARM DAFF DRILL ROLLES, FERTON HILL, NEW HEXICO Randy Langy and A. William Laughlin (Geomejances Division, Los Alenos National Laborstory, Los Alamos, New Maxico 87545) Examination of 46 chin-sections of Pracambrian betamorphic and igneous rocks from three deep drill boles in northern New Hexico reveals a marrow dempth remeature refuse for senselles of

4270 Properties of singrals NEAR-INFRARED SPECTRAL REFLECTANCE OF MINERAL HIS-TURES: SYSTEMATIC COMBINATIONS OF PROXEMES, OLIVINE, AND IRON OXIDES OLIVINE, AND IROW OXIDES R.B. Eloger (Planetary Geosciences, Maysii Inst. of Geophysics, Univ. of Hawsii, Nonolulu, HI 96822) Near-infrared spectral reflectance data are

Near-infrared spectral reflectance data are presented for systematic variations in weight percent of two component mixtures of ferro-agentian and iron-oxide micrals. Mixtures were chosen for application to the study of the derk materials on Hars, but the results are equally applicable to mafic and mirramafic amemblages elsewhere in the solar system. Olivine appetral features are greatly reduced in contrast by admixture of other phases but remain distinctive even for low olivine contents. Clinopyrozane and orthopyroxane mixtures show resolved pyroxane absorptions mear 2 ms. The addition of liminate greatly modifies pyroxane and olivine reflectance but does not fully eliminate distinctive appetral characteriaties. Using only apetral data in the lum region it is difficult to differentiate orthopyroxane and insonite (geothics) in a mixture. Additional spectral coverage or other evidence may be required for a unique interpretation. All composite mineral absorptions observed in this study are either waker than or interpretation in a trangit to the andsember a requal to those for the andsembers. In general, spectral properties in an intimate mixture combine in a complex, non-additive manner, with features demonstrating a regular but usually non-linear variation. All composite representations.

J. Geophys. Res., Red. Paper 180712

Vanyan L. L., Yudin M. N. The Fifth All-Union Seminar on electromagnetic so-

3743 Pagnetuspheric configuration
SPATIAL DISTRIBUTION OF PYFRUPTIC PARTICLES IN
INC. SPATIAL DISTRIBUTION OF PYFRUPTIC PARTICLES IN
INC. SPATIAL DISTRIBUTION OF PYFRUPTIC PARTICLES IN
INC. SPATIAL ASSOCIATION OF PYFRUPTIC PARTICLES IN
Inc. SPATIAL STATE OF SPATIAL OF SPATIAL
D. J. Militans
The spatial distribution of energetic particles in the distant nigner-viall is emusical by
using identical sers of two complementary energetic particle experiments abused the 189-3 and
8 spacecraft. The confined 189-7 and A data wor
provides nearly 19 years of extellite observation. The quantitative distributions of energetic electrons in two energy trages (30
keV x E a loss keV, 720 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
emergetic protons (50 keV x F x 1.5 NeV) and
perpendicular to also successful the color of the following
his asymmetry to greate and protons to the
evening side. The degree of asymmetry difference
for electrons and protons and for electrons
for electrons for protons and for electrons
for electrons and protons and for electrons
for electrons and protons and for electrons
for electrons and protons and

estely one order of wignitude. J. Geophys. Res., Sius, Paper Lading? 5755 Places instabilities SIMULATION OF THE CURRENT-CRIVEN ELECTROSTATIC propriate an instabilities simulating of the copression of the consistent insertigation of the growth and saturation of current-driven insubstities along arroral faild kines. Ion exclotten waves are found to grow to lead early the copression of the growth and saturation of current-driven insubstities along arroral faild kines. Ion exclotten waves are found to grow to lead early to 0.2 -0.4, which are comparable with the levels observed by the 30-1 ascellite. In the present indical-value calculations, asturation is due to platest formation on the electron distribution function. Excitation of the long exploren waves leads to miderate the 401 perpendicular heating of the lone but does not produce a high-energy tail. The specialed grandlous resistivity is relatively and 1, 1/4pc 1 is 10° in longituations of those results for observation of ton exclotron waves on auroral field lines are discussed. Geophys. Res. Lett., Paper 110726 Geophym. Ras. Lett., Paper 110/26

Geophys. Res. Lett., Parer 110/26

\$755 Plasma Instabilities
THE ROLE OF HISS IN MAGNETOSPHERIC
CHORUS EMISSIONS
H. C. Keons (The Aerospace Corporation,
P. O. Dox 9457. Los Angeles, CA 90003)
Many researchers have reported that carrowband hiss emissions are simulatedously present
with ell chorus emissions outside of the plasmasphere. In data from the SCATHA satellite
chorus emissions are often observed to start at
frequencies that are within a hiss band. Hiss
band spectra averaged for 6.4 s with a resolution of 5 Hs are very smooth. Retative maxima
are typically less than 2 db above adjacent
minima. Spectra obtained on a 200 nu sample
show large variations in emplitude between
adjacent bios with relative maxima 18 to 15 db
above adjacent minima. Electrons in a sarrow
range of energies and pitch angles can be
urganized in phase by the dopler-shifted cycloiron resonance with the larger amplitude tron reconace with the larger amplitude spectral components in the his band. The bandwidth of the cyclotron resonance is found to be sufficiently narrow so that the electrons are not dephased by waves in adjagent portions of the highly structured spectrum. The amplitude of the high is sufficient to significantly phase bunch the electrons in the calculated interaction since. The chorus emission is then generated as the phase bunched electrons moved adiabatically along the geomagnetic field line. No evidence for mosuchromatic aigust waves such as power line harmonic radiation are found in the SCATHA data within the higs bacde from which above is pobserved to be triggered. This the SCATIA data within the hise bands from which should is observed to be triggered, mechanism can also account for the observa-smirs into detected at frequencies above a li-band to the Joylan magnetosphere. (Chocus emissions, whistiers, hise). J. Geophys. Rus., hive, Paper 140764

5785 Shistler Statist States of SHIJILDS OF SHIJILDS OF SHIJILDS OF SHIJILDS

ANTIFICAT SATE PAOFALATION AT LOW LATIFIES H. Blingh (Department of Physics, R. B. B. College, Biohpari, Agra, India-283103) and R. Biohpari, Agra, India-283103) and R. Bicket of parallel electric fields on whistler wave propagation in studied with the help of ray tracing computations. It is shown that in the presence of such fields the whistler ray paths are defocused and their final wavenorsals at the base of Fregion lose sphare in the opposite hemisphere are such that the waves would not be observed on the ground. In the absence of suitable ducks borisontal density gratients was ting in the low latitude lessesphere seem to play important roles in whistler propagations to ground atsitoms (Whistler electric fields; wave normals ray paths)

J. Geophys. Res., Blue, Paper 140319